UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1938

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By J. T. Jardine and F. D. Fromme[1]

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PART 1—ORGANIZATION OF RESEARCH IN THE EXPERIMENT STATIONS

INTRODUCTION

For the great majority of the State agricultural experiment stations, the fiscal year 1938 marked the close of a half century of work under the provisions of the Hatch Act of March 2, 1887. Although 37 States and the Territory of Dakota had organized experiment stations in conformity with the terms of the act prior to June 30, 1888, and received allotments of $15,000 each for the fiscal year 1888, the work of that year was for the most part preliminary to the real beginnings of experimental work in the fiscal year 1889. Since the first appropriations under the act were made by Congress February 1, 1888, and the first disbursements to the station treasurers March 15, only a few months remained of the current fiscal year during which expendi-

[1] With the collaboration of other members of the Office staff.

tures could be incurred. This was in most instances insufficient time for the governing boards of the stations to do much more than appoint directors and authorize disbursements for physical plant and equipment. In many of the States, formal organization of the stations had been delayed pending the voting of grants by Congress. Only 12 States and the Territory of Dakota had organized new stations or reorganized existing stations under the Hatch Act in the interim between March 2, 1887, and February 1, 1888. The act of February 1, 1888, appropriated $585,000, "or so much thereof as may be necessary" for the fiscal year ended June 30, 1888, the amount being based on an estimate that 38 States and 1 Territory were prepared to proceed with the work of an experiment station during that year. Following the approval of this act, the governing boards of some 26 land-grant colleges which had not hitherto taken definite steps toward the establishment of experiment stations proceeded with their formal organization in time to permit the use of the first appropriations.

The Rhode Island Station, which had been included in the estimate of 38 States, did not complete its organization in time to be eligible for the grants of 1888. The first director was appointed and work of a preparatory nature was begun November 3, 1889. However, the full amount of $15,000 which would have been available for 1888 was later disbursed for the use of the Rhode Island Station under a deficiency appropriation act approved April 4, 1890. Thus a total of 38 States and 1 Territory (later the State of South Dakota) participated in the grants for 1888, and at the close of the fiscal year 1938 had received annual grants under the authorization of the Hatch Act for a continuous period of 51 years.

Following the division of the Territory of Dakota and the organization of the North Dakota Station October 15, 1890, the State of North Dakota became eligible for grants under the Hatch Act. The new station at Fargo participated in the annual appropriations thereafter, along with the older station at Brookings, S. Dak., established under the territorial government.

By July 1, 1893, all of the nine States that had not organized experiment stations in time to receive the first grants under the act had accepted its terms and completed the organization of their respective stations. The Arizona, New Mexico, and Utah Stations were not organized in time to be included in the appropriations for the fiscal year 1889, but received $10,000 each for that year under a deficiency appropriation act approved April 4, 1890. In 1928 the benefits of the Hatch Act were extended to Hawaii, to Alaska in 1929, and to Puerto Rico in 1931. The respective stations were organized under the act of July 1, 1929, May 1, 1931, and November 14, 1933.

The dates of organization or reorganization of the separate experiment stations, and of legislative assent by the State, territorial, and insular governments are recorded in table 2 of this report.

Section 9 of the Hatch Act provided that the grants of moneys which it authorized were subject to the legislative assent of the several States and Territories to the purpose of these grants. It, however, permitted payment on the assent of the governor of installments becoming due to any State before the adjournment of the regular session of its legislature meeting next after the passage of the act. An amendment to the Hatch Act approved June 7, 1888, further author-

ized the Secretary of the Treasury, upon receipt of a certified copy of the assent of the governor of a State or Territory, when the legislature was not in session, to pay "such installments of the appropriations [authorized by the Hatch Act] as may be now due or may hereafter become due."

In accordance with these provisions, the legislatures of the States recorded their assents to the purposes of the grants authorized by the Hatch Act, the dates of assent, in general, falling within the first regular session following approval of the act. Of the 39 States and Territories included in the grants for the year 1888, 25 recorded formal assent by legislative act prior to June 30, 1888, the others being qualified for receipt of their allotments through the assent of their governors. The Legislature of Utah likewise recorded its assent prior to June 30, 1888. Within the fiscal year 1889 the legislative assents of 15 additional States were recorded and the assents of the remaining 7 were completed by February 16, 1893, by an act of the Legislature of Montana.

That rather well-defined and generally accepted ideas concerning the character, functions, personnel, and organizational structure of agricultural experiment stations existed in the United States prior to the passage of the Hatch Act has been brought out in a discussion of the policies and procedures involved in this act on the occasion of the fiftieth anniversary program of the subsection of experiment station work.[2] These standards "of such common usage as practically to constitute common law" had been evolved during a period of more that a decade of the carrying on of experiment station work by State experiment stations and land-grant colleges prior to the passage of the Hatch Act. The background of their experience was the basis on which the specifications of the act were written.

Of the 50 State agricultural experiment stations currently participating in the grants under the Hatch Act, 15 had been definitely organized and had functioned as experiment stations prior to the passage of the act. All but one had been formally recognized by the legislature of the State and received some measure of State support either through appropriations or fees derived from fertilizer control work. Some were established by State law with no formal affiliation or administration by the trustees of the land-grant college, others by State law which placed their administration under or in close affiliation with the land-grant college. A third group had their origin in acts of the governing boards of colleges or universities and later received State recognition and support.

The first group includes the Connecticut (State) Station, continued as a permanent institution by legislative act March 21, 1877, after having received State support in 1875 and 1876; the North Carolina Station established by act of March 12, 1877; and the New York State Station and the Ohio Station established by the legislatures of the respective States August 5, 1881, and April 17, 1882. The Louisiana Station, which was organized by the State Bureau of Agriculture in February 1886, had received preliminary authorization by the legislature in 1884 in anticipation of the passage of the Hatch Act.

[2] TRULLINGER, R. W. THE POLICIES AND PROCEDURES INVOLVED IN THE HATCH ACT FROM THE STANDPOINT OF EFFICIENCY IN ADMINISTERING PRODUCTIVE RESEARCH. 51st Ann. Conv., Assoc. Land-Grant Cols. and Univs. Proc., 1937 : 144–147.

The group of stations established by State law with close affiliation with the land-grant college includes the New Jersey State Station organized under an act of March 10, 1880, with the management vested in a board of directors, consisting of the Governor, the board of visitors of the State agricultural college, and the president and professor of agriculture of that institution. The other stations of this group were set up more definitely as branches of the land-grant college with the same administrative boards. The dates of the legislative acts creating them were: Massachusetts Station, May 12, 1882; Wisconsin Station, April 2, 1883; Alabama Station, 1883; Maine Station, March 3, 1885; and the Vermont Station, November 24, 1886.

The California, Tennessee, and Kentucky Stations were established by the governing boards of the universities or agricultural and mechanical colleges of those States and later received legislative recognition and support. State appropriations for the California Station were first received in 1877. The Tennessee Station in 1883 and the Kentucky Station on April 13, 1886, were designated by State law to carry on certain phases of the fertilizer-control work and to use the fees for the expenses of this work and for conducting experimental work.

The New York (Cornell) Station was unique among the stations antedating the Hatch Act in that it was established as a voluntary enterprise of the faculty of the College of Agriculture with the affiliation in the early days of several agricultural organizations and farmers' clubs which were represented on the board of control. The station was organized in February 1879 and first received appropriations from the trustees of Cornell University in 1881.

Beside the 15 experiment stations included in the foregoing discussion, the agricultural colleges of at least 14 States had carried on considerable experimental work in agriculture prior to the passage of the Hatch Act. In some of these the work was quite as extensive, noteworthy, and well organized as in the States having formally organized stations. The experience gained in the work of these institutions likewise contributed materially to the movement for Federal support of State experiment stations and helped to form the pattern of the Hatch Act and the type of organizations established under it.

The agricultural colleges of Pennsylvania, Michigan, and Maryland, which had been founded in the late fifties before the passage of the Morrill Act, early began experiments in the testing of varieties of crops, the use of fertilizer, and such other lines of work as their facilities permitted. In agricultural colleges first established as land-grant institutions experimental work was carried on in Nebraska, Minnesota, Kansas, Iowa, Illinois, Indiana, New Hampshire, Missouri, Colorado, Mississippi, and South Carolina prior to the organization of Hatch experiment stations. It is to be noted that in some of these States the legislatures had included experimental work in the charters of the colleges and had appropriated funds for the purchase of experimental farms.

Although experimental work in agriculture had gotten under way in some 29 States before March 2, 1887, it remained for the Hatch Act to bring formal State recognition and support for such work in many of these States, and to inaugurate experimental work in the other 19 States. In authorizing Federal grants for agricultural research the

act not only furnished support for new or enlarged programs of work, but it founded a system of Federal-State cooperation in research which has had far-reaching effects within the half century since its inception. Through its administration there has evolved out of the earlier patterns of organization a group of research institutions having unity of purpose, function, and obligation, with established identity as scientific agencies for public service, and unbroken records of accomplishment for the benefit of agriculture and the general welfare.

COORDINATION AND COOPERATION IN CURRENT RESEARCH

The interest of station directors in the continuance and expansion of cooperation between the States in agricultural research was reflected in a discussion of this topic during the convention of the Association of Land-Grant Colleges and Universities in November 1937. Although a very substantial amount of cooperation between State experiment stations is now taking place, relatively little of it is of a formal type. In contrast, the cooperative relations between the Department of Agriculture and the stations are in the main covered by formal memoranda of understanding. The informal arrangements existing between stations, which may consist merely of correspondence between staff members working on a common problem or of group discussions at meetings of scientific societies, are effective and useful. They are often the forerunners of more formal understandings. Relative to the current status of interstate cooperation, the director of the Kansas Station said in part:

> However, rugged individualism appears gradually to be giving way to group consciousness as workers have an opportunity to work together and to appreciate the advantages that accrue to them personally from a cooperative attack on a problem. Institutional pride and professional jealousy is giving way to pride in the accomplishment of the group as a whole and an increasing realization that the interest of every single individual in any research organization is dependent in part at least upon the progress made by the institution as a whole.

There were in effect during the fiscal year 1938 more than 1,350 formal agreements covering research between the State experiment stations and bureaus of the Department. These involved all of the stations and all but one bureau. They covered nearly 1,000 major research undertakings and represented a substantial increase over the previous year. Problems involving the action and adjustment programs were especially emphasized. In 35 States, for example, certain phases of the national study of adjustments in farming by regions and type-of-farming areas were continued with the cooperation of the Agricultural Adjustment Administration, the Bureau of Agricultural Economics, the Forest Service, the Farm Security Administration, and the Soil Conservation Service.

The national survey of research in soil science and related problems was completed during the year, and provided part of the material on soil science published in the Yearbook of Agriculture, 1938. The survey involved the cooperation of all Department bureaus concerned with soils, soil science, and land use, and all of the State experiment stations.

Research on cotton diseases in which 12 State experiment stations are cooperating as a group and with the Bureau of Plant Industry was expanded and strengthened. Investigations leading to the improve-

ment of cereal crops were extended to include 21 States, and studies of machinery for the mechanical application of fertilizers to cotton, potatoes, sugar beets, and canning crops, and for the production and harvesting of sugar beets and corn involved 18 stations, of which 7 completed the work during the year.

The range survey, which covered 7 distinct regions, was cooperative between 17 western stations, 4 Department bureaus, and the Department of the Interior. Cooperative soil survey work was conducted in 29 States. Other cooperative studies included the breeding and culture of potatoes in 17 States, a study of farm population and farm-population movements in 12 States, fertilizer and forage-crop investigations, studies of the conformation and anatomy of the dairy cow, studies of cereal and forage-crop insects, and investigations of the quality and palatability of meat. Each of the latter studies involved 11 stations and appropriate Department bureaus.

Memoranda of understanding covering relationships in research between the Soil Conservation Service and 47 State experiment stations were effective during the year, and definite lines of soil conservation research were undertaken with 36 stations. The Bureau of Agricultural Economics likewise participated with the Soil Conservation Service in studies of the economic and social effect on farms resulting from the operation of definitely planned programs of soil conservation which were conducted in 17 States.

The project on the nutritional status of college women entered the third year of the 5-year plan at the six cooperating north-central stations. At the yearly conference of the project leaders, plans were made for the publication of papers on techniques developed to date, and for the analysis of data on about 800 anthropometric measurements. The studies on vitamin C which are active in two groups of experiment stations, one in the Northwest and one in the Northeast, afforded opportunity for comparisons between the two regions. The subject of variation in composition of vegetable foods grown in different areas of the South was made the basis for a plan of work that will integrate the work of chemists, horticulturists, and home economists of several southern stations with representatives of the Bankhead-Jones regional vegetable breeding laboratory.

COOPERATIVE RESEARCH UNDER THE BANKHEAD-JONES ACT

The very considerable recent acceleration in the volume and effectiveness of coordinated and cooperative research, of which the foregoing few examples have been cited, may be attributed in part to the influence and opportunities afforded by the Bankhead-Jones Act of June 29, 1935. The provisions of title I of this act for the establishment, maintenance, and operation of research laboratories in major agricultural regions has not only had the effect of promoting the integration of the research of the Department and stations along the lines of work established at these regional laboratories, but has also promoted group thought and action on other problems of a regional character. The allotments to States and the appropriations for special research fund projects of the Department of Agriculture under this title have likewise greatly aided the movement towards teamwork in the solution of problems which transcend the borders of individual States and have regional or national significance.

Regional laboratories.—The procedure followed in establishing the regional laboratories under the Bankhead-Jones Act was designed to insure so far as possible the effective cooperation of the Department and the stations. The final decisions as to the program of work and location of the eight laboratories established to date were made on recommendations worked out in regional conferences by representatives of the Department of Agriculture and the directors and selected scientific workers of the State experiment stations. Such conference groups organized for the consideration of regional laboratory programs readily found other matters of common interest, and in some instances where regional organizations had not been in existence the directors established conference groups for the purpose of continued cooperation with the laboratories and for the discussion of other research activities of the region.

The organization plan of each laboratory provides for the appointment of a collaborator as recommended by the director of each of the stations of the region, and continued unity of action among the technical workers is thus provided for. The collaborators meet at least annually with the directors of the laboratories and representatives of the Department to review progress and formulate plans for future work. The personnel engaging directly in the cooperative work of these laboratories during the year was approximately 150, of which 51 were station representatives, and 77 employees of the Department having headquarters at the laboratories. Some 22 representatives of the Department having headquarters in Washington, D. C., participated in the work in advisory and supervisory relationships.

The two new laboratories established during the year included the regional laboratory for the improvement of viability of poultry, approved December 23, 1937, with headquarters at Michigan State College, and the regional salinity laboratory, approved on the same date, with headquarters at Riverside, Calif. The former will serve as a research center for the study of causative agents and control of fowl paralysis for the northeast and north-central regions, and is organized in cooperation with the experiment stations of the 25 States comprising these regions. The regional salinity laboratory will study basic aspects of problems involved in the accumulation of soluble salts or alkali in irrigated lands of the western region, and will coordinate the work in this field of the Department and that of 11 Western State stations and Hawaii.

The six regional laboratories established prior to 1938 made satisfactory progress during the year in perfecting organization plans and research facilities, in working out details of projects, and in getting research under way. Promising results were obtained where the programs had been in progress long enough to make possible the accumulation of sufficient data to indicate trends or warrant interpretations. This was true of the three laboratories established in 1936—the vegetable breeding laboratory at Charleston, S. C., which serves 13 States of the southeastern region, the pasture research laboratory at State College, Pa., serving 12 Northeastern States, and the soybean industrial products laboratory at Urbana, Ill., for the 12 States of the north-central region.

The three regional laboratories established in 1937 were so organized as to permit effective conduct of research work toward the close

of 1938. These are: The laboratory for the improvement of swine through breeding, with headquarters at Ames, Iowa, in cooperation with 12 North Central State stations, the laboratory for the improvement of sheep through breeding, coordinating work in 12 Western States with the central laboratory at Dubois, Idaho, and the laboratory for the study of contagious, infectious, and parasitic diseases of domestic animals and poultry at Auburn, Ala., with a program adapted to the needs of 13 Southeastern States.

Special research fund projects.—While some of the 44 special research fund projects of the Department of Agriculture active in 1938 were of a type most readily prosecuted in the laboratories of the bureau or bureaus concerned, many of them were cooperative with the experiment stations or other agencies, both public and private. Typical of the latter was the investigation of the possibilities of long-range weather and crop forecasting, including a study of the relation of weather to crop yields. The cooperative services of 11 bureaus of the Department and many of the State experiment stations have been employed in a total of 56 projects which have been initiated during the 3 years of special research fund allotments to the Department under the Bankhead-Jones Act.

FEDERAL INSULAR STATIONS

The Office of Experiment Stations continued to have direct administrative supervision of the Federal stations in Puerto Rico and Hawaii. In conformity with a plan that has been in effect since 1929, the Federal station in Hawaii was completely merged with the Territorial station at the close of the year, the merger having been effected on a graduated scale. Since then the two stations have operated under a single director. Except for an unexpended balance of approximately $1,494 originally made available to the Federal station under sugar-processing tax-fund allotments, and continued available until expended by the Supplemental Appropriation Act, fiscal year 1936 (49 Stat., 1116), the relationships of the Office of Experiment Stations to the Territory of Hawaii in agricultural research hereafter will pertain only to the use of the Federal-grant and offset funds.

HAWAII STATION

As provided by the sugar-processing tax-fund orders, seven projects were continued under allotments of these funds as follows: Taro investigations, liver fluke eradication, rat abatement, development of truck farming and improvement of marketing facilities, development of livestock feeds, development of tropical fruits and nuts, and promotion of the poultry industry. Rodent-control work was done in cooperation with the Bureau of Biological Survey, and chemical studies of the papaya were cooperative with the Bureau of Chemistry and Soils, United States Department of Agriculture. Cooperation was also extended to the Soil Conservation Service in a preliminary soil-erosion survey, supplementing the detailed soil survey which has been in progress by the Bureau of Chemistry and Soils.

The income of the station during the year was $220,481.32, which included $15,000 Hatch, $15,000 Adams, $20,000 Purnell, and $6,889.80 Bankhead-Jones funds; $79,500 Territorial funds; $2,066 the final

direct Federal appropriation; $79,906 of tax-fund allotments; and $2,119.52 from the Hawaiian Sugar Planters' Association for rodent-control work.

PUERTO RICO STATION

The primary function of the Federal station at Mayaguez is to serve national interests and responsibility in agricultural investigations in the Tropics, while that of the insular station at Rio Piedras is to solve local agricultural and rural life problems. The two stations naturally have intermediate problems of joint responsibility requiring complementary activities, and since each in serving its major function may serve the function of the other, they are linked in scope and function.

As an outpost of the Department of Agriculture in the Tropics, the Federal station carried on a considerable part of its work in cooperation with other agencies of the Department. The facilities at Mayaguez are proving of particular advantage as a winter breeding station, as, for example, in the case of sweetpotatoes which flower and set seed readily in Puerto Rico and but rarely in the continental United States. The breeding work of the Bureau of Plant Industry has been materially advanced by means of seed produced from a large number of controlled crosses and self-pollinations of continental varieties of sweetpotatoes made in 1938, together with a large quantity of open-pollinated seed of Puerto Rican varieties.

Other work cooperative with the Bureau of Plant Industry included studies of environmental conditions essential to the growth of quinine, in which considerable progress was made, and studies of rotenone-yielding plants which gave evidence that rotenone content may be influenced by agronomic practices as well as the inherent capacity of individual plants. The latter work was also cooperative with the Bureau of Entomology and Plant Quarantine, which likewise cooperates with the Puerto Rico Station in the introduction of insect predators and parasites. A particularly outstanding result of this work was the successful introduction and multiplication of the Amazon fly, a parasite of the moth borer of sugarcane and corn.

Considerable improvement was made in methods of seed germination and of processing vanilla beans for the production of vanilla, the work being cooperative with the Bureau of Chemistry and Soils. Housing facilities were furnished for the work of the Forest Service and the Soil Conservation Service in the islands.

Work designed especially for local benefit included the development of new uses of bamboo; the experimental propagation of spice crops, including ginger, nutmeg, and cinnamon; new developments in extracting and utilizing the essential oils of lemon grass, ylang ylang, and ambrette; and successful trials in the canning of mangoes.

More detailed results of research accomplishments in Puerto Rico and Hawaii are included in part 2 of this report.

PART 2—PROGRESS IN THE SOLUTION OF AGRICULTURAL AND RURAL LIFE PROBLEMS

While it is true that the dominant and over-all objective of experiment station research has always been the promotion of economic and social progress in agriculture and rural life, the social implications of

research programs of earlier days were less clearly defined and the economic applications quite different in character than today. Of late the planning of research projects and the interpreting of results have been more consciously designed to effect the solution of economic and social problems, and recognition has been given to technical studies in the physical and biological sciences to parallel and supplement the agricultural economic and rural sociological fields as contributing factors in economic and social progress. Consequently, the sciences are being brought to bear more and more on the objectives of making farming more successful and rural life more livable under the conditions of today and those of tomorrow.

Where the emphasis of earlier years in much of the agricultural research was properly on the expansion of production to assure more adequate supplies of agricultural products for a growing population and to sell abroad, the efforts of today are designed to make possible planning for permanence and economic stability. Health and enjoyment, and modernized homes as essential parts of efficient farming have an important place in these current trends. Studies are also being directed to the problems of tenancy, marginal lands, and low-income groups.

The dominant public movement toward economic well-being, adequate housing, abundant health, and enjoyment of life for all of the people is reflected in the research of the State experiment stations, and is the essential motive in all of their work. Contributions directed specifically to these ends will be noted in the examples of the results of the work of the stations during 1938 which follow, many of these being cooperative with the Department of Agriculture and other Federal agencies. For example, agricultural planning and land use studies of national and regional application have been given increasing attention, as have also such special problems as the rehabilitation of drought-stricken, soil-blown, and flooded lands. Cultural and varietal practices for replacement crops in adjusted production programs and for erosion prevention have received new emphasis in the light of current needs. The direction of research toward profit margins, market demand, and consumer requirements and preferences has also been evident. Current trends in health and social welfare are to be seen not only in the results and application of nutritional studies but likewise in housing where planning of homes for adequacy and convenience is receiving attention.

The scope of this report does not permit a review of the stations' contributions to new knowledge in detail or in any degree of completeness. The material presented is selected as a representative sample of the work of the 53 State and Territorial experiment stations and the Federal Puerto Rico Station as reported in their publications and in special reports from the directors. The reader is referred to these publications for more complete information.

PLANT PRODUCTION, PRODUCTS, DISEASES, AND INSECT PESTS

The wide range of climatic conditions existing in the continental and territorial areas of the United States permits the cultivation of a large and very diverse array of crop and ornamental plants, some of which are endemic and others of more or less recent introduction. Their culture, improvement, soil management, protection, and utili-

zation presents a multitude of problems which require the continuous attention of many research scientists of the State experiment stations and Department of Agriculture.

FIELD CROPS AND WEED CONTROL

CONTENTS

Prominent features of the current research with field crops at the State experiment stations include the improvement of cereal, fiber, oilseed, forage, sugar, and root crops and tobacco in yield, resistance to diseases, insects, and adverse environmental factors, and in market and technological qualities; betterment in cultural and harvesting practices involving modern implements and machines; the effective and economical use of properly balanced fertilizers; conservation of soil and soil fertility by cultural practices, rotations, and other practices; perfection of methods of crop storage and handling; and the control of weeds by chemicals and cultural methods. In addition, the stations were dealing with such special problems as cultural and varietal practices for drought-stricken, soil-blown, and flooded lands; and special and replacement crops in land use and crop-control programs. Agronomic phases of the greatly expanded pasture research throughout the country, discussed elsewhere in this report, also received serious attention. Many of the problems have extended far beyond the limits of single States and have best been coped with by cooperative action among several or many stations and the Department of Agriculture. These broader activities are, of course, in addition to the more fundamental phases of research which provide information on which to base studies having more immediate application, and the numerous variety, soil-fertility, cultural, and harvesting tests, often more or less conventional or local, yet necessary in the broad industry of agriculture.

Selected examples of accomplishments in research with the several field crops are presented in the following pages. A more complete picture of the work in progress will be provided if the results summarized here are examined in connection with those published in several preceding years.

COTTON

Research in cotton production continued with the objectives of more productive and disease-resistant varieties, better fiber quality, effective fertilization, and economical cultural and field practices, all leading to substantial yields of high-quality fiber at reasonable production costs.

Change in cotton-culture methods.—The Texas Station and the Department of Agriculture (B.A.E.) cooperating found out that in little more than a decade, cotton farmers in the High Plains of Texas had replaced one-row equipment with two-row and four-row implements, and practically had replaced animal power with mechanical power. As a result, the amount of cropland that can be handled by a farm family has increased in this period from about 100 to about 450 acres. Implications are that far-reaching social and economic changes necessarily must follow.

Varieties.—That it is the seed planted, and not the weather and soil, that largely determines spinning quality of cotton produced even under widely varying environments was indicated in regional cotton studies during 3 years by the Department of Agriculture (B.P.I.) and 14 experiment stations in 10 leading cotton States. Variety seemed to be the most important single factor in determining such qualities as staple length and fineness and to a certain extent, strength of fiber. Contrary to popular opinion, none of the 16 varieties studied varied more than one-eighth inch and often as little as one-sixteenth inch in staple length whether grown in the Mississippi Delta under optimum moisture and soil conditions or on the western fringe of the Cotton Belt.

From extensive outlying variety experiments the Arkansas Station concludes that not more than eight varieties would be required to plant all the principal types of land in the Arkansas Cotton Belt. On the basis of individual performance at different locations, the varieties are, for the Delta and river-bottom land, D. & P. L. 11A and Delfos 719 as medium- to short-staple varieties, Stoneville 5, where land is not too poorly drained, and Coker Wilds 7 for long-staple; on second bottoms and fertile uplands, Stoneville 5, Roldo Rowden 40–2–9, Arkansas Rowden 5056 and 4046, Delfos 719, and Arkansas Acalas 1114 and 4067; in regions approaching lowland conditions, D. & P. L. 11A; and in hilly sections and on thin upland soil, Stoneville 5 and the three Rowden strains.

A new strain of Delfos (Delfos 2323–965–425) developed through selection at the Louisiana Station proved to be very resistant to *Fusarium* wilt, surpassing standard wilt-resistant varieties such as Dixie Triumph and Cook 307–6 and also having excellent staple, good yields, and most of the desirable qualities of Delfos. A new strain of Acala cotton (37A) developed by the New Mexico Station and released to farmers in the Pecos Valley in 1938 is earlier, staples about one-sixteenth inch longer, and has a greater degree of uniformity in length of fiber than ordinary strains of Acala grown in New Mexico. Another strain (1517) was being increased in 1938 for release in the Mesilla Valley in 1939.

Seed treatment.—Acid-delinted cottonseed usually germinated faster than fuzzy seed and gave almost perfect stands in cooperative tests by the Tennessee Station and the Department of Agriculture (B.P.I.). The station published on the construction of an inexpensive seed-delinting drum with advice on its operation, planting rates, and the merits of acid-delinted seed. By means of a special osmometer designed to use small pieces of seed coats, the Arizona Station demonstrated that the cottonseed testa is a natural semipermeable

membrane, and that concentrated sulphuric acid increases the permeability of the testa for water.

Fertilizers.—Studying the needs of cotton grown on different soil types, the North Carolina Station found that phosphorus was particularly effective on Davidson clay loam and only slightly less on Georgeville sandy loam in the Piedmont. Yield increases resulting from phosphorus applications on Coastal Plain soils were less striking, although profitable increases ordinarily were obtained. Increase in percentage of phosphorus resulted in an earlier crop as measured by percentage of total yield at first picking. The Georgia Station in tests with cotton observed that calcium metaphosphate, fused rock phosphate, monocalcium phosphate, dicalcium phosphate, and tricalcium phosphate did not differ much from superphosphate in effectiveness.

Certain coastal prairie soils and the lighter Coastal Plains soils, the Louisiana Station found, are low in available potash. The lighter soil types appeared also low in nitrogen and phosphorus, and best results were obtainable from potash used in a balanced mixture. The Crowley soils seemed low in phosphorus and available potassium and also to respond to completely balanced fertilizer. Control of cotton rust and wilt by potash fertilizers seemed usually to accompany stimulation of vegetative growth and increased yields of seed cotton. Decreases in the length and percentage of lint where potash starvation occurs could be corrected by use of potash fertilizer. Striking responses of cotton to potash were secured by the South Carolina Station at the Pee Dee Substation on sandy loams low in available potash. Yields rose consistently with applications up to 75 pounds per acre, potash giving best results when applied before planting. On Cecil sandy loam where deficiency in potash was marked, the Georgia Station secured better results per pound of potash from kainit than from chloride. Greater response to potash in neutral fertilizer compared with acid fertilizer was obtained in two locations.

Growing cotton in water cultures, the Georgia Station found that the limiting concentration of manganese for growth approximates 1 to 100 million parts of the culture medium. Cotton fails to function normally when manganese goes below this level, whereas there is danger of toxicity above 1 part per million. A peculiar type of dwarfing and abnormal growth of cotton in certain areas of fields in cultivation for many years was determined by the North Carolina Station as due to excessive acidity which increases the solubility of manganese in the soil. That such soluble manganese was the cause of the peculiar plant growth was demonstrated by treating plants in sand cultures with manganese. It was determined also that ordinary agricultural lime applied to these acid soils would control the trouble. Dolomitic limestone surpassed rock phosphate, calcic limestone, and dolomitic limestone as fillers to correct acidity in mixed fertilizers in Georgia Station tests.

Of all fertilizer placements tested for cotton, the Texas Station again found that the best germination of cottonseed and the highest yields were obtained when the fertilizer was placed to the sides and below the seed level. The location of the fertilizer in relation to the seed affected germination more than yield. When the fertilizer was

placed within 1 inch of the seed, germination was injured. Placement experiments by the North Carolina Station cooperating with the Department of Agriculture (B.A.Eng. and B.P.I.) demonstrated that fertilizer could be placed in two bands 5 to 6 inches apart and the cotton planted between the bands with a walking planter with as good results as obtained with a more expensive machine that applies the fertilizer in two bands and plants the seed simultaneously. Placement of the fertilizer 3 inches to one side of the bed and planting with a walking planter in separate operations did not give a satisfactory stand or yield.

The residual effect from nitrogen of fertilizers on cotton was very marked at three locations where fertilizer experiments were conducted in 1928–36 by the Georgia Station, the greatest effect being on Cecil and Norfolk sandy loams and the least on Carnegie sandy loam. Residual effects from phosphates and potash were very erratic, a small effect being obtained on Cecil sandy clay loam. On plats fertilized with various nitrogen carriers in 1926–34 on Cecil sandy clay loam planted in wheat in 1936, much greater residual effect followed ammonium sulphate with limestone than after sodium nitrate.

Fiber quality.--The relation of certain physical fiber properties of cotton to spinning quality, as studied by the North Carolina Station cooperating with the Department of Agriculture (B.A.E. and B.P.I.), indicated that a small fiber diameter, a heavier fiber weight, and a longer staple length are associated with higher yarn strength. The results suggested that the cotton breeder should select and propagate cotton strains having such characteristics.

That a consistent correlation exists between fiber length and maturity was indicated from analyses by the Arizona Station. The maturity of Pima cotton fibers gradually decreased as the length increased, and the longest fibers in the Acala variety were likewise usually the most immature. In selecting for uniformity in length by discarding plants producing both the long and short fiber classes in excess, breeders are also improving the maturity of cotton fibers.

Study of uniformity of length of cotton has resulted in the development of sorting machines for separating fibers into class lengths. An automatic, motor-driven sorter devised by the Arizona Station handles a 10-seed sample in less than one-third the time needed on hand-operated machines, and the lint can be recovered in $\frac{1}{32}$-, $\frac{1}{16}$-, or $\frac{1}{8}$-inch classes, or in nearly any combination of classes desired. The use of this machine in making plant selections has resulted in considerable increase in uniformity of the lint of the Acala and Stoneville varieties. The Arkansas Station has designed a device for rapidly sorting cotton fibers attached to the seed as to length by use of a photoelectric cell. Information is readily provided on modal length, mean length, and percentage of fibers in any length class.

The New Mexico Station found frosted or frozen cotton to be poorer in quality and yield than cotton opened normally. The quality was poor due to wastiness because the lint was weaker-fibered or immature. It seemed probable that frosted or frozen cotton is the reason irrigated cotton of the Southwest is currently in disrepute with some spinners. The station was striving to develop earlier and better-quality cottons to overcome this objection.

When certain cotton varieties were grown year after year and mixing with other varieties was avoided, the Mississippi Station found that lint percentage always declined and the yield of seed cotton usually declined, the combined result being a decrease in yield of lint cotton, as a rule less than 20 pounds to the acre per year. The significance of this lies mainly in the regularity with which it recurred.

Fibers in 6 distinct varieties studied by the North Carolina Station and the Department of Agriculture (B.P.I.) cooperating were found to have an essentially similar developmental history. The lint hairs evidently originate when or soon after the flower opens, while the first fuzz hairs appear only after the lint population has been fully determined. The period of fuzz initiation takes place from 5 to 10 days after the flower opens.

CORN

Hybrid corn.—The production of hybrid seed corn, an enterprise based largely on research of the experiment stations, often cooperating with the Department of Agriculture (B.P.I.), has within a few years developed into an important agricultural industry. Supplies of hybrid seed corn for spring planting in 1938, it was estimated, would suffice to plant nearly 15,000,000 acres, about one-seventh of the total corn acreage in the United States, or about five times as much hybrid seed as was available in 1937. The greater portion of this seed was available only to farmers in the North Central States, especially Iowa, Illinois, Ohio, Indiana, Wisconsin, Minnesota, and Nebraska, in decreasing order. Each of the experiment stations in the Corn Belt States and also in several other States conducted experiments to appraise the merits of hybrid versus open-pollinated corn for yield, resistance to drought, lodging, and diseases, and for agronomic qualities such as adaptation to certain fertility conditions, and to machine harvesting. A number of the stations have worked out definite policies for the distribution of seed of inbred lines and single hybrids to growers and cooperative associations.

Estimates of the Illinois Station were that farmers in Illinois planted more than 1,000,000 acres to hybrid corn in 1937, and the acreage was expected to exceed 5,000,000 in 1938. Practically all the hybrids ranked above the five best open-pollinated varieties in general performance in the station's State-wide tests. The five best hybrids averaged for all tests 12.5 bushels per acre higher than the five best open-pollinated varieties in sound corn and 24 points above in percentage of erect plants. That the superiority of the better hybrids over open-pollinated corn was greater on highly fertile soils than on poorer soils was demonstrated again. Comparing different genetic strains of corn, the station observed that swine, mice, and rats distinctly preferred certain strains, suggesting that such preference should be considered in improvement.

In the Iowa Station annual corn-yield test in 1937, in cooperation with the Department of Agriculture (B.P.I.) and a growers' association, the yield of hybrid corn averaged 16.4 percent more than that of open-pollinated varieties, with the greatest relative increase in districts suffering most from drought. A hybrid excelled in yield in

each of 12 districts. The results showed again that not all hybrids are good, and the grower should buy seed only of known and adequately tested hybrids. Methods followed in cooperative corn improvement by this station are outlined, and inbred lines and hybrids developed and released for commercial production are described in a station bulletin.

Other stations in Northern States also reported promising corn hybrids. Michigan Station tests indicated Michigan Hybrid No. 1218 and Minnesota Hybrid No. 402 as early corns for most purposes in northern districts, and Michigan Hybrid No. 561 for grain in southern Michigan and for silage farther north. The New Jersey Station Hybrid No. 2 decidedly outyielded local varieties in several tests and progress was made in securing the more general planting of these hybrids and certified seed corn. About 25,000 acres of the double-crossed silage corn known as No. 29–3, developed by the New York (Cornell) Station, were grown in 1938, and seed for 75,000 acres should be available in 1939. Although No. 29–3 has outyielded commercial corns by over 10 percent, several new double crosses promise to outyield No. 29–3 by an equal percentage.

The Ohio Station showed that the straighter stalks and the more uniform height of the ears of hybrid corn greatly increase the operating efficiency of mechanical pickers. In fields of standard varieties the pickers failed to get from 8 to 10 percent of the ears, while the same machines in harvesting hybrid corn left only from 0.5 to 1.5 percent of the ears. The planned program for the production of seed of adapted corn hybrids developed by the Ohio Station, the Department of Agriculture, and other agencies, advanced to the point where in 1937, 260 growers produced commercial supplies of seed, a group of 320 apprentices was gaining experience with $\frac{1}{8}$- or $\frac{1}{4}$-acre crossing plats, and seed production had been initiated in each of the 88 counties.

Several experiment stations in the Southern States have had only limited success in producing valuable corn hybrids. However, Louisiana Hybrid No. 123, developed by the Louisiana Station cooperating with the Department of Agriculture (B.P.I.), averaged 53 bushels versus 45.5 bushels from Cocke Prolific, outyielding it by from 18 to 27 percent in three localities and making 4 percent less in another. Corn-breeding work by the Florida Station indicated that hybrids might be produced that would yield 15 to 30 percent more corn and be more resistant to weevils than its new weevil-resistant varieties. The Georgia and Tennessee Stations found hybrid corn from various sources to be inferior to native varieties in yield and other characters.

Color of corn plants.—Corn in which the sun-red color (anthocyanin pigment) was increased by breeding work at the Wisconsin Station substantially outyielded corn of the ordinary green color containing no anthocyanin. Breeders plan to incorporate the color into stocks of hybrid corn for increase in yield and to denote superior quality.

The Minnesota Station found in 19 inbred lines of corn wide differences in percentages of carotinoid pigments, a variation not associated closely with intensity of yellow endosperm color. A positive asso-

ciation was found between the percentage of chlorophyll and carotinoid pigments in the leaf tissue.

Origin of corn.—Genetic and cytological studies on corn and its relatives at the Texas Station have culminated in a complete revision of theories regarding the origin of corn. They indicate that teosinte, formerly thought the progenitor of corn, is the product of a natural hybrid of corn and *Tripsacum*. Archaeological and historical evidence indicates that corn as a domestic plant had its origin as a mutation from a wild form of pod corn in South America. Hybridization of corn and *Tripsacum* to produce *Euchlaena* has also given rise to new types of corn and it is believed that most North American varieties carry some *Tripsacum* genes in their germ plasm.

Cold tolerance.—Cold-tolerant strains of corn appeared in Illinois Station studies to have better stalk insulation against cold than did susceptible strains. Such tolerance seemed to be a function of proteins. Natural cold tolerance in a strain of corn in the seed stage could be retarded temporarily by soaking the seed in certain chemical solutions; the same chemical treatment might impart an induced cold tolerance to an otherwise susceptible strain.

Stabilized corn production and soil fertility.—Regularity of corn production is more beneficial to farmers as a group and to society in general than is either failure or extreme overproduction. Effects of soil treatment in stabilizing yields of corn were evident in corn-yield data from 15 years' work by the Illinois Station on 17 soil experiment fields in Illinois. The fertile, dark-colored Corn Belt soils produced high yields with a high degree of regularity from year to year, while untreated poor land was very irregular in corn production. Soil treatment on the poor or moderately fertile soils greatly improved stability of corn production except on sandy soil, where treatment raised the yield level but reduced yield fluctuation only slightly. The most successful treatments on poor and intermediate soils failed to bring either their average yield or regularity up to the level of treated corn on better soils.

The Illinois Station also reports that 1937, the sixty-eighth year in which corn had grown continuously on certain Morrow Plots, was the sixth time plats have grown corn in the same year. Yields in bushels per acre for 1937 were for continuous corn with no treatment, 43.1 bushels, and with manure, limestone, and phosphate 60.8 bushels. Corn treated similarly but alternating with oats made 44 and 76.4 bushels and corn in rotation with oats and clover made 67.4 and 87.1 bushels, respectively. These results also demonstrate the merit of good fertility practices.

The practice of using cover crops in conserving soil productivity with continuous corn was found highly desirable by the Rhode Island Station. Clovers were the most effective for the purpose, although rye also gave decided benefits. Increased grain yields were proportionately greater than stover yields. Both kinds of cover crops lessened the rate of decrease of soil nitrogen and increased the water-holding capacity of the soil.

Production practices.—Recent trends in corn-production research are away from the simpler types of variety and cultural tests, yet these remain necessary in many areas. For example, in corn experiments

by the Wyoming Station in Campbell County in 1927–36, hardy flint and dent varieties that mature from early to midseason appeared to ripen and yield well. Spring seedbed preparations usually produced higher average yields than fall-prepared seedbeds, fall plowing returning lowest yields. Early spring plowing outyielded early spring disking. Deep spring plowing did not give profitable increase in yields over ordinary plowing. Plantings from June 1 to 15 outyielded plantings made from April 15 to May 15 and needed fewer cultivations. Furrow-planted corn yielded higher than surface-planted or listed corn. Regularly spaced (42-inch) corn rows outyielded wider spacings in years of normal rainfall, but in drought years 84-inch rows equaled 42-inch rows and in those years winter wheat yielded more after the 84-inch rows.

WHEAT

Improvement.—Better wheat varieties characterized by winter hardiness, earliness to evade hot summer winds, drought resistance, greater resistance to diseases and insects, stiffer straw to facilitate combining, and superior milling and baking qualities were the objectives of wheat breeding by the stations, often in cooperation with the Department of Agriculture.

A number of the newer varieties of wheat released to growers in recent years were being grown on rapidly increasing acreages. Examples are Tenmarq, a hard red winter wheat, early, stiff-strawed, resistant to stem rust in mature plant stage, and of good baking quality, and Kawvale, a soft red winter wheat, winter-hardy, stiff-strawed, resistant to leaf rust and hessian fly, and tolerant to stem rust, both by the Kansas Station; Rex, a soft white winter wheat, high-yielding, early, and resistant to lodging, shattering, and smut, and of good quality, by the Oregon Station; and Thatcher, a hard red spring wheat with high yields, earliness, stiff straw, stem rust resistance, and high milling and baking qualities, by the Minnesota Station; all developed in cooperation with the Department of Agriculture (B.P.I.). Rigorous tests in Canada and Great Britain also confirmed the superior milling and baking quality of Thatcher wheat, which is being grown extensively in the northwestern spring wheat belt where its behavior was noteworthy in the rust epidemics of 1935 and 1937. V. P. I. 131, a productive strain of Fulcaster, by the Virginia Station, and Yorkwin, the white wheat released by the New York (Cornell) Station, cooperating with the Department of Agriculture (B.P.I.), as resistant to loose smut and good for pastry flour, were reported as increasing in acreage and making high yields.

Nebred, a selection from a winter-hardy Turkey wheat, made by the Nebraska Station and the Department of Agriculture (B.P.I.) cooperating, and released for fall planting in 1938, is highly resistant to races of bunt new in Nebraska but not to stem rust, is very winter-hardy, and gives high yields of grain of high test weight and of good milling and baking qualities. Early Premium, a new soft winter wheat developed and being increased for distribution by the Missouri Station, matures 10 days to 2 weeks earlier than commonly grown varieties and thus is especially suited as a nurse crop for grasses and legumes and to a 1-year crop-rotation system. One of the progenies from Ridit × Baart (No. 1076–3) of the Arizona

Station and the Department of Agriculture (B.P.I.) is apparently immune to the form of smut commonly found in Arizona, has a better straw than Baart, and is a good grain yielder.

Pilot (N. No. 1098), developed by the Department of Agriculture (B.P.I.) in cooperation with the North Dakota Station, was being increased for commercial distribution. The result of a Hope × Ceres cross, it is resistant to both stem and leaf rust, has outyielded Thatcher by more than 3 bushels per acre at Langdon over 6 years, and is of high bread-making quality. Another new spring wheat, Rival (Ns. 2634), to be released in 1939 by the North Dakota Station, cooperating with the Department of Agriculture (B P.I.), combines rust resistance of Hope, drought endurance of Ceres, and kernel size of Florence wheat, has good milling and baking qualities, and has outyielded other spring wheats in tests in 1934–37. Work with durum wheat has been aided by a new method that permits the testing for quality of small samples of early segregating strains. The test employs a small mixer, a miniature roller, and a laboratory hydraulic press, and uses about 0.25 pound of wheat instead of the 5 pounds formerly needed. The semolina is processed into macaroni disks instead of tubes.

Resistance to crop hazards.—Cooperative winter-hardiness studies in 1930–37 by the Department of Agriculture and a number of stations in the Great Plains and Canada indicated Lutescens 0329, Buffum No. 17, and Minhardi as the most hardy winter wheats available. Lutescens 0329, Minhardi, and a few hybrid strains were grouped as hardy; Minturki, Turkey (C. I. 6152), and Nebraska No. 60 as midhardy; Cheyenne, Kanred, Oro, and Kharkof as slightly hardy; and Quivira, Blackhull, Tenmarq, and Early Blackhull as tender. Winter survival in 30 different soft winter wheats under study in 1933–37 by the Indiana Station varied from 5.2 to 80.4 percent in the field and from 2 to 76.6 percent in artificial freezing tests. Soft wheat varieties were not so winter-hardy as semihard wheats under Indiana conditions; they possess a weaker gluten and a lower proportion of carotenoid pigments, but produce a finer flour.

The average lodging in winter wheat varieties as determined by the Texas Station and the Department of Agriculture (B.P.I.) cooperating was correlated significantly with breaking strength of straw and with weight per unit length of stem near the base of the plant, secured by the use of a simple method. These characters were more accurate for evaluating lodging resistance than a single season's observation of lodging or of several other characters.

Shattering is an important problem in the Pacific Northwest where harvest covers 2 to 3 months and much wheat stands for 2 to 3 weeks after ripening and is often subjected to high hot winds and low relative humidity, resulting in cases of losses of 4 to 15 percent among several commercial varieties. Efforts are being made to obtain resistant varieties that will thresh easily. The Washington Station and the Department of Agriculture cooperating found that wheat varieties more resistant to shattering have the greater proportion of lignified tissue at the breaking point of their outer glumes, and that the lignified band at the inner epidermis did not continue above the breaking point so prominently in susceptible varieties as in resistant wheats. Direct determination of the force needed to break glumes

from mature spikelets appeared to provide a better criterion of shattering resistance.

Hail damage causes an annual loss to Iowa farmers estimated to exceed $4,500,000. Consequently, hail insurance is an important item. Iowa Station studies designed to answer questions that often confront the hail-insurance adjuster showed that complete destruction of aboveground parts on May 11 increased the percentage of injury from 70 percent for wheat to total loss on June 1; whipping severely enough to break all wheat plants increased the percentage of injury from 25 percent on May 11 to 77 percent on June 15; bruising the developing heads before they had emerged reduced yields from 9 percent on May 25 to 20 percent for June 15; and breaking the stems about the middle so that the heads hung straight down reduced yields from about 44 percent in June to about 80 percent at maturity. Similar tests were also made on barley and oats.

Wheat production.—The Indiana and Missouri Stations issued bulletins showing trends on the latest developments in methods and practices. The Wyoming Station, publishing practical information on growing wheat on dry land and under irrigation, reports that winter wheats yielded more per acre under dry-land conditions than did spring wheats, while the reverse was true under irrigation. Fall plowing for spring wheat evidently should be practiced on irrigated land in order to permit early seeding. If spring wheat follows a cultivated crop, disking and floating may suffice. The station emphasized that wheat should be planted early so as to take advantage of early spring moisture.

The Montana Station in tests of the 1935 and 1936 crops of lightweight spring wheat found that weight per bushel was closely associated with laboratory, greenhouse, and field germinations and also with wheat yield—the heavier wheat producing the greater germination and the higher yields.

Quality.—New wheats, strains being developed in the breeding programs, and older varieties were being appraised by the stations as to milling and baking quality. Research of this character was expected to advance through the work of the new Regional Wheat Research Laboratory established at Manhattan, Kans., by the Department of Agriculture and cooperating stations to test the various wheats in the major hard red winter wheat States.

Quality studies in the wheat-breeding program of the Minnesota Station in cooperation with the Department of Agriculture (B.P.I.) indicated a close relationship between loaf volume and color, texture, and grain. The relation between test weight, protein content, and milling yield was not apparent when varieties of diverse origin were compared. Milling yield was independent of all factors affecting baking results.

Large variations in grade, test weight, and flour yield were observed by the North Dakota Station among samples of hard red spring wheat grown in different counties in 1937, a severe rust year. Protein content varied from sample to sample of wheat, and this was reflected in corresponding flour samples. However, the excellent baking results showed high quality in the current crop. The importance of test weight to flour yield and of wheat protein to flour protein, which in turn was highly related to loaf volume, was evident.

Color of loaf crumb tended to increase with test weight. Thatcher gave the most satisfactory results of the varieties tested.

Wheat grown on the well-defined spots, usually from 2 to 3 feet in diameter and often observed in small-grain fields in Kansas, compared with adjacent areas by the Kansas Station, made greater growth, contained a much higher percentage of nitrogen and total quantity of nitrogen, was equally resistant to lodging, and yielded very much more grain that was significantly higher in protein content than grain from the field at large. Soil from the spots averaged higher in nitrogen and in nitrate content than adjacent soils and could accumulate nitrate nitrogen much faster. Typical spotting under Kansas conditions was attributed to the nitrogen in the urine deposited by grazing animals and could usually be produced experimentally by surface application of nitrogen.

Selenium.—When Tenmarq wheat was grown by the Kansas Station on Derby soil in the greenhouse and not allowed full winter dormancy, its early germination was aided by light applications of selenium; whereas early growth (fall) was depressed in proportion to the amount of selenium applied. Applications of 6 or more parts per million killed the wheat, the earlier death resulting from the heavier applications, while applications up to 2.5 parts per million stimulated spring growth and harvest weight.

OATS

Improved varieties.—The value of a Nation-wide cooperative breeding program with oats involving several stations and the Department of Agriculture (B.P.I.) has been demonstrated by the production of a number of promising new strains of oats. A considerable portion of the present oat acreage of the Corn Belt is grown to improved early varieties—developed cooperatively by the Iowa Station and the Department—such as Albion (Iowa 103) Iowar, Richland (Iowa 105), and Iogold. Although Richland and Iogold have been especially outstanding because of high yield and excellent resistance to stem rust, they lack resistance to crown rust and to smut. The introduction from South America of Victoria oats with high resistance to crown rust and smut, and Bond, an Australian oat with similar resistance, has provided valuable material for breeding still better varieties. Certain selections from Victoria × Richland made at the Iowa Station averaged 98 bushels per acre in 1937 versus 85 bushels from Richland, have resistance to crown and stem rust and smut, and desirable grain characters. They promise to be of special value in sections of the Corn Belt where oats often suffer from rust and unfavorable conditions. Other promising lines of midseason oats with resistance to the rusts and smuts have been developed from Markton × Rainbow oats.

Bannock, a new smut-resistant oat developed from Markton × Victory by the Idaho Station in cooperation with the Department of Agriculture (B.P.I.) and released in 1938 to farmers of the irrigated sections of southern Idaho, is also characterized by high yield and good quality. Fulton, a selection from Fulghum × Markton oats made by the Kansas Station in cooperation with the Department of Agriculture (B.P.I.), has marked resistance to smut, heads about 3 days earlier than Kanota but ripens at about the same time, has aver-

aged (7 years) 8.2 bushels more grain per acre in the nursery, and has yielded slightly higher in the field. It also outyields Kanota from late spring planting but is less resistant to spring freezes.

Lee oats (Winter Turf × Aurora), an outstanding product of the cooperative breeding program, due to its winter hardiness and high yield, as well as good kernel quality, is considered by the North Carolina Station as well suited to the Piedmont section of the State. A selection from Lee (No. 5) has even outyielded the parent which surpassed practically all varieties in tests in 1925–38 at Statesville.

BARLEY

Improvement.—Varieties characterized by resistance to diseases, smooth awns permitting easier harvesting, better malting quality, and good yields were the aim in barley-improvement work at the stations.

Marnobarb and Selections 19–8 and 15–8, three barley strains with awns practically free from barbs, developed by the Maryland Station from crosses between Velvet and Tennessee Winter barleys, have outyielded Tennessee Winter in both straw and grain, although somewhat less winter hardy.

The New Jersey Station has found the Maryland smooth-awn barley and Missouri Early Beardless, winter types, and Comfort, a spring type, more satisfactory in winter hardiness and yield than varieties commonly grown. Their earliness permits them to be grown with soybeans as a grain crop in the same year. A new smooth-awn barley selected by the New Mexico Station that consistently outyielded the best barbed-awn types has been increased for release to farmers.

The quality of malting barley samples from farms in different parts of the Thumb district considered with comparative yields in 1934–37 of varieties at the Michigan Station indicated that Michigan malting barley can be improved in both quality and yield by growing and properly handling an acceptable standard variety, such as Wisconsin No. 38. Its smooth awns make for proper shocking, its low percentage of blue kernels is desirable for the maltster, and its greater yields are more profitable to the grower.

Malting tests of barley varieties raised in the principal growing areas, made at the regional laboratory at Madison, Wis., by the Department of Agriculture and cooperating experiment stations in the malting barley area, revealed that varieties of the Manchuria-Oderbrucker type were superior in quality to the smooth-awned sorts developed earlier. The tests on malting methods in progress involve such factors as the percentage of moisture reached in the steep, temperature of steep water, temperature during malting, and length of time malted. Preliminary indications were that malting methods have a decided influence on the quality of malt produced. The results secured are expected to find practical application in commercial malt houses.

Barley production.—The Maryland and Iowa Stations recently summarized the results of their research and that of other stations in bulletins of information on barley growing. The Iowa Station points out that barley has outyielded oats in Iowa, yet 15 times more acreage is grown to oats. Acre yields in 1930–33 of Trebi, Wisconsin 38, Glabron, Spartan, and Velvet were so nearly equal that vari-

etal choice must be based on other characters. No other cultural practice studied gave as great an increase as did early planting, which is especially recommended. Ripening dates, plant heights, bushel weights, and yields were modified slightly by fertility, but lodging was increased by each fertilizer treatment. Lack of tolerance of all varieties for nitrate was noteworthy; it increased lodging and depressed yields even when in a complete fertilizer.

RYE

Improvement.—Raritan rye, developed by the New Jersey Station, has outyielded the common rye of the region and certain well-known varieties. It is the combination of 98 productive lines out of 216 strains continued for 5 years after selection of superior plants from a mass variety containing 10 varieties and strains after 2 years of natural crossing. The merits of this system have been published by the station.

Prolonged inbreeding with selections of Schlanstedt and Abruzzi rye by the Wisconsin Station showed that vigor in vegetative growth is usually less in the inbreds than in open-pollinated rye. Fertility in inbred lines has been increased by selection, averaging not over 6.5 percent in the first 5 years of inbreeding and selection, approximating 50 percent in the last 4 years. Some crosses between inbred lines showed hybrid vigor and surpassed open-pollinated rye while others were too inferior for continuation. The average fertility of first- and second-year selfing and selection of hybrids compared closely with that of the tenth and eleventh years' inbreds.

RICE

The stations in the rice-growing States of Arkansas, California, Louisiana, and Texas, cooperating with the Department of Agriculture (B.P.I.), were investigating problems of rice production concerned with varietal improvement, culture, irrigation, fertility, and disease control.

Fertilizers.—Large increases in the growth and yield of rice were obtained by the Louisiana Station on rather poor Crowley silty clay loam from the addition of leguminous organic matter, i. e., soybean hay. Commercial fertilizers were not so effective, but substantial yield increases followed applications including phosphorus. Inorganic nitrogen and potassium did not do well alone or together, but were effective with phosphorus. Fertilizers were particularly beneficial when applied in a localized area around the seed. Nitrates in the soil dropped rapidly after flooding and were not detectable at harvest. Ammonia nitrogen also declined but more slowly. Available phosphorus declined similarly except where applied as ammophos and bonemeal.

Hybridization.—Emasculation of rice florets, by the Louisiana Station and the Department of Agriculture (B.P.I.) cooperating, by immersion in water at 40° to 44° C. for 10 minutes gave a better seed set than did clipping. Covering the panicles was not necessary, and the crossed seeds developed and germinated normally. Similar but less satisfactory results were obtained with water at from 0° to 6°. Bagging panicles with glassine increased seed set in clipped but not in unclipped florets.

SEED FLAX

The production and improvement of seed flax, a crop of major importance in North Central States, have received more and more attention in other sections of the country from experiment stations cooperating in most cases with the Department of Agriculture (B.P.I.). The Texas Station, growing flax as a winter crop in southeast Texas, reported yields of 10 to 15 bushels per acre on dry land and from 25 to 30 bushels under irrigation, compared to about 7 bushels as an average yield for the United States. Estimates were that 10,000 acres or more would be planted in the fall of 1938.

Flax growing.—The Kansas and Idaho Stations also provided farmers with informational bulletins on seed-flax growing in their respective States. The Idaho Station suggests from experiments and experience the use of the Bison variety, sown as early as possible at the rate of 3 pecks per acre on clean weed-free soil. A firm seedbed, receptive to moisture, and rather frequent light irrigations, especially during the blooming and early filling stages, are recommended. The crop should be thoroughly ripe when cut with a binder and completely dry when threshed.

Natural crossing.—In seven flax varieties, grown in 1931–33 by the Department of Agriculture (B.P.I.) cooperating with the Minnesota and Montana Stations, the average percentage of natural crossing ranged from 0 to 1.88, with a maximum of 5 percent in Blanc. Highest percentages were observed in the large-flowered varieties Blanc and Pale Malabrigo, much less in the tubular-flowered Indian type 68, and practically none in Bison. Flowers opened at sunrise on clear days, pollination occurred at once, and fertilization of ovules within 3 hours afterward.

PROSO

Proso, or hog millet, an important feed-grain crop on the nonirrigated lands of eastern Colorado, is well adapted to the hard lands but less productive than corn on sandy lands. It is grown largely as a short-season, late-sown catch crop and as such may follow or precede any other annual crop satisfactorily. Experiments by the Colorado Station, cooperative with the Department of Agriculture (B.P.I.), indicated that proso should be drilled at the per acre rate of about 35 pounds of seed immediately after a rain, from about June 15 to July 1. Turghai, an open-panicled sort with yellowish-brown seed, made the highest average yield, 15.9 bushels, and Yellow Manitoba 14.4 bushels, both maturing in about 70 days after planting. Their respective average yields were 20.6 and 19.01 on summer fallow with no failures and 11.2 and 9.7 bushels, respectively, on Sudan grass stubble where two failures occurred.

POTATOES

Research directed toward solution of the many problems involved in growing, protecting, and marketing potatoes was active at most experiment stations and often was cooperative with the Department of Agriculture. That information gained in such research is adopted by the growers is apparent from a consideration of the potato industry in New Jersey, where the average yield in 1911–15 was 103

bushels per acre compared to more than 180 bushels in recent years. New Jersey growers now produce nearly as large a potato crop on 50,000 acres as they did in 1911–15 on more than 90,000 acres. The New Jersey Station attributes this improvement in yield to better production methods, as better seed, spraying, proper use of fertilizers, elimination of unadapted soils, and seed disinfection.

Improvement.—The Mesaba potato, a result of breeding work by the Minnesota Station cooperating with the Department of Agriculture (B.P.I.) and other stations, was derived from a cross between Russet Rural and a seedling selection of Early Ohio. Mesaba is a round white potato of the smooth Rural type and is similar to Irish Cobbler in maturity and yield. In Minnesota it has proved to be a smoother, more attractive market potato than the Irish Cobbler. Mesaba is resistant to some virus diseases but susceptible to others. Its shallow eyes and uniformly smooth surface appeal to the housewife in making for easy peeling with a minimum of waste. Warba, the earliest maturing potato in the State, has gained wide popularity since its distribution in 1933 by the station.

The Michigan Station reports progress in the development of seedling varieties of potatoes adapted to muck soils and particularly those resistant to scab. The New York (Cornell) Station among others has shown that immunity to blight (*Phytophthora infestans*) and probably drought tolerance are heritable. Blight-immune and drought-tolerant potato varieties of good quality evidently can be produced. Variations in tolerance of different varieties of potatoes to psyllid yellows were reported by the Wyoming Station, but it had yet to find a variety that was immune to the disorder. Tolerance, yielding ability, and earliness appeared to be related.

Breeding methods.—Many seedlings that outyielded northern-grown Triumph seed were found by the Louisiana Station, especially with cold-storage seed held from spring to spring or from fall-grown heated seed potatoes, i. e., stored at about 70° F. until planting. Maturity determination in the greenhouse when combined with field observations, the Minnesota Station found, may increase the reliability of the estimate of the breeding value of a parent for quick maturity. The Nebraska Station has published practical suggestions for the testing of seedling potato stocks for specific horticultural factors under controlled conditions.

Storage of seed.—Eastern Shore home-grown Irish Cobbler seed potatoes exposed to relatively high temperatures for a short period just before planting by the Maryland Station outyielded similar seed held longer at lower temperatures and had about the same amount of virus diseases. Evidently late-grown Eastern Shore seed might be caused to germinate and mature as early as northern- and mountain-grown Irish Cobblers which, at ordinary temperature, germinated and matured about 10 days earlier. Yields of Louisiana fall-grown Triumph potatoes planted 30, 60, and 100 days after harvest by the Louisiana Station varied directly with time between harvesting and planting. Fall-grown seed kept at 60° to 75° F. from harvest to planting outyielded seed kept in unheated common storage. All lots produced considerably less than western dry-land certified seed. The Ohio Station has perfected the details of a method for growing and storing a fall crop of Irish Cobblers for seed.

Seed and planting practices.—For good stands of potatoes, especially with the late- or main-crop planting, the Nebraska Station from its experiments and experience specifies good seed that has not lost much weight in sprouting, protected from the sun or hot drying winds, and planted in moist soil. If moisture conditions are unsatisfactory, stand possibilities may be improved by cutting seed several days before planting, healing under proper conditions, and then planting and covering deeply and perhaps packing the soil after planting, or, if available, irrigation water should be applied before plowing or planting. Stands generally are better with early than with late plowing and plantings, with large than with small seed pieces, and with small rather than with large tubers. Seed of potatoes of several varieties, grown on peat soil by the Wisconsin Station, has outyielded seed from mineral soils when compared on several soil types.

Results secured by the Department of Agriculture (B.P.I.) working at Presque Isle, Maine, and cooperating with several State stations, indicated that seed potatoes can be cut from 10 to 30 days before planting with slight decrease in yield, provided cut seed is properly suberized and cared for in storage between cutting and planting. Sun greening of seed tubers before fall storage, the West Virginia Station found, apparently has no practical value.

Seed-spacing and fertilizer studies on the Gulf coast by the Alabama Station showed the highest net returns from 2,000 pounds of fertilizer with 1-ounce seed pieces spaced 12 inches apart or 1,500 pounds of fertilizer with 1½-ounce seed pieces 16 inches apart. The need was shown for a balance between the quantity of fertilizer applied and the quantity of seed used.

Between May 15 and June 1 was indicated by the Colorado Station as an optimum time for planting in mountain valleys and under irrigation for Avon. Potatoes planted too early are not as uniform in shape and size and if planted too late do not mature and the yield is reduced.

Fertilizers.—Growers in the Charleston, S. C., area have followed profitable fertilizer and other production practices resulting from experiments of the South Carolina Station. Examples are replacement of expensive organics with the cheaper nitrogen carriers, such as sodium nitrate and ammonium sulphate, the use of limestone or basic slag, especially on acid soils, and the use of the band-placement fertilizer drill and potato planters. Other helpful practices include dusting for late blight only when weather conditions may warrant, a type of information made available by the station; a shift from barrels to bags and even tubs as containers; digging machines and electrically operated graders; and also the practice of washing the tubers before packing for market.

That potatoes require large quantities of nitrogen, phosphorus, potassium, magnesium, and calcium, especially from 50 to 80 days after planting, was shown by the Virginia Truck Station. During such a 30-day period 1 acre of potatoes absorbed nitrogen at the rate of 1.66 pounds daily, phosphorus 0.3, potash 3.33, and magnesia 0.3 pounds daily. A nonacid-forming fertilizer mixture increased the yield of potatoes on unlimed plats of this station but only slightly

influenced it on limed land. Neutral and acid-forming fertilizer mixtures showed no apparent difference as to severity of scab.

Green Mountain potatoes under continuous culture in 1929–37 on Charlton loam soil at the Connecticut (Storrs) Station yielded highest when fertilized with 100 pounds of nitrogen, 160 pounds of phosphoric acid, and 120 pounds of potash per acre, but when alternating with clover and timothy, usually cut for hay, in a 2-year rotation, potatoes did not make higher yields from more than 50 pounds of nitrogen or 120 pounds of phosphoric acid, although needing about as much potash as under continuous culture. The importance of rotation for assuring better yields in adverse years was indicated.

Potatoes were shown by the Rhode Island Station to be very responsive to applications of magnesium in magnesium sulphate, and other carriers. High levels of potash in soils accentuated magnesium deficiency. The Connecticut (Storrs) Station found that potatoes responded significantly to both lime and magnesium on depleted Merrimac sandy loam in 1935–37, and to insure against possible deficiencies advised that potato fertilizers should include both lime and magnesium or the land be treated with dolomitic limestone.

That potatoes have responded to applications of phosphorus, which encourages root development and starts the crop off ahead of untreated potatoes, is reported by the Montana Station. Tuber set occurs earlier and is generally increased, yields are heavier, and a higher percentage of the tubers class as No. 1 grade, thus definitely increasing possibilities of profits. Beneficial effects of phosphate fertilizers, observed by the Colorado Station, were increased dry-matter content, slightly increased starch, and definite improvement in appearance, maturity, and handling qualities of potatoes. Addition of potash fertilizers, it was noted in many instances, has tended to reduce yield and produce thin-skinned yellowish colored tubers. The station states that commercial fertilizers do not affect yields where potatoes have been planted after alfalfa or sweetclover.

Green manure.—The value of plowing under cover crops on potato yields was shown by the Virginia Truck Station. Potatoes following sorghum, soybeans, or a mixture of the two plowed under yielded about 150 bushels of primes per acre, after a cash crop 113 bushels, and after soybeans harvested for hay only 99 bushels. That summer legumes turned under before an early crop of potatoes are responsible for only small increases in potato yields for the first 2 or 3 years was reported by the Alabama Station. However, continued use of a summer legume in a definite soil-improvement system resulted by the fourth year in a material increase in potato yields, apparently due directly to nitrogen added by the legume, and in higher soil productivity.

Preceding crops of rutabagas, millet, alsike clover, and red clover consistently resulted in decreased yields of Green Mountain potatoes at the Rhode Island Station, whereas higher potato yields followed onions, oats, winter rye, redtop, and squash.

Potatoes in Alaska.—The settlements in the Matanuska Valley of Alaska have provided a ready market for potatoes at prices ranging from $2 to $4 per 100 pounds. The Alaska Station reports that the crop grown on well-drained sandy loam and stored properly is of high quality. Acre yields in its 1937 tests were from Early Ohio 233 bush-

els, White Bliss 230, Irish Cobbler 221, and Netted Gem 201 bushels, and a variety known as Arctic Seedling made 282 bushels. The station points out the need for research on disease control as well as for increase in yield and improvement in quality.

Composition.—Four varieties of potatoes differed significantly in composition when grown in 1934–36 in five localities by the Colorado Station. Tubers in one locality might differ in starch, dry matter, protein, and ash from those of another locality, and varieties might differ similarly. Differences in dry matter, protein, and ash between years were also found. Irrigated potatoes were higher in starch and dry matter but lower in protein content than dry-land potatoes. Addition of mineral fertilizers did not change materially the mineral composition of tubers, except where specific minerals were deficient in the soil. Decline in production of good quality potatoes in certain districts of Colorado has been found due to loss in market quality or appearance rather than to deterioration in chemical composition or cooking quality of the potato.

The effects of variations in major plant foods and of copper, manganese, magnesium, boron, and iron on chemical composition, especially in sucrose, starch, nitrogen content, and protein: starch ratio, and on cooking quality of potato tubers have been determined by the New York (Cornell) Station.

SWEETPOTATOES

A number of stations, especially in the South, have devoted much effort to the improvement of the sweetpotato and cultural methods with the aim of making it a more important cash crop.

Improvement.—The Louisiana Station has developed technique for inducing standard varieties of the sweetpotato to bloom and set true seed. Plants carried over winter in coldframes or in greenhouses in pots are shifted to the field early in the spring and fertilized heavily with superphosphate. As soon as the trellised vines have made satisfactory growth they are girdled and then bloom and set seed. Girdling alone caused plants to bloom 30 days earlier than the controls. The station also observed that to bloom and set seed, sweetpotatoes evidently must be old enough to have accumulated carbohydrate reserves in the vines. They bloomed most freely with an 11.5-hour day and set seed best with increasing day length from 11.5 to 12.5 hours. Each variety or group appeared to have definite conditions for blooming and setting seed.

Although sweetpotatoes rarely flower and set seed naturally in the continental United States, they do so in Puerto Rico. This has enabled the Puerto Rico Federal Station to undertake sweetpotato breeding for the Department of Agriculture (B.P.I.). More than 3,000 controlled crosses and self-pollinations were made in 1938 with 13 continental American varieties and more than 1,200 seeds resulting from these and open-pollinations and 10,000 open-pollinated seeds of Puerto Rican varieties were sent to the Department.

Sweetpotato production.—Sprout-production experiments by the South Carolina Station showed that roots bedded in loam produced more sprouts per root and per bushel and usually required lesser weight of root to produce a unit weight of sprout than those bedded in sand. It was indicated that shallow bedding will

produce more sprouts per root and per bushel than deep bedding, particularly during the first 3 or 4 weeks of plant production. Moderately large roots produced more sprouts per root, somewhat larger individual sprouts, and slightly fewer sprouts per bushel than the small roots and may be considered as economical. The marked variation in plant production shown by individual roots of Porto Rico sweetpotatoes indicated the possibility of selecting high plant-producing strains that bring forth most of their sprouts early.

Working on three soil types, the Mississippi Station found that the Triumph sweetpotato grown in southern Mississippi gradually builds up the proportion of starch in its roots during the growing season, which extends from the time roots are large enough to sample until early October or until plant growth ends. Increasing the fertilizer potash from 4 to 16 percent had no apparent effect on proportions of the various grades nor on the shape of roots.

TOBACCO

The stations in tobacco-growing States cooperated as usual with each other and with the Department of Agriculture in efforts to determine the best varieties; effective plant-bed, cultural, fertilizer, harvest, and curing practices; and control of diseases and insect pests.

Improved hybrid.—A hybrid tobacco resistant to mosaic developed at the Connecticut (State) Station by crossing a good strain of Broadleaf tobacco with Ambalema, a resistant South American type, has plants similar to Broadleaf and practically immune to the disease.

Field practices.—Productive and time-saving practices indicated by Ohio Station experiments with cigar-filler tobacco include bagging of heads of desirable plants for seed at bloom to prevent cross-pollination by insects; sprouting seed before sowing in plant beds, the latter preferably on well-conditioned soil steamed each year at 125 pounds pressure for 25 minutes or 150 pounds for 20 minutes; setting in the field June 15 to 25; suckering twice; and growing an adapted variety.

The new tobacco-seed cleaner developed by the Kentucky Station is of the blower type and does not employ sieves, separates heavy and light seed effectively, and has been found satisfactory for cleaning both small and large lots of seed.

Seeking the optimum time of harvest, the Connecticut (State) Station determined that Havana Seed tobacco increased in weight of crop and in grading for 3 weeks after topping, the higher yield being due to increase in leaf size and thickness. The longer the tobacco remained in the field after topping the more quickly it cured and the less it was affected by poleburn. Early and medium pickings of shade tobacco were worth much more than late pickings.

Fertilizers.—The experiment stations in Virginia, North Carolina, South Carolina, Georgia, Florida, and Tennessee again joined with the Department of Agriculture (B.P.I.) in recommending for the 1939 crop, analyses, rates per acre, and carriers of nutrients in fertilizers for flue-cured, sun-cured, and shipping tobacco, and for plant beds on tobacco soils, based extensively on their cooperative research.

For Burley on good sod land, Kentucky Station experiments indicate from 300 to 400 pounds of fertilizer applied at the row and containing from 4 to 5 percent of nitrogen, from 8 to 12 percent of phosphoric acid, and from 6 to 8 percent of potash, and from 500

to 800 pounds on less productive soils. Usually from 8 to 10 tons of manure per acre, supplemented by about 200 pounds of superphosphate at the row on soil low in phosphate, will give better quality tobacco than complete fertilizer. For dark tobacco on productive soils, from 200 to 300 pounds per acre of a 3–8–6 or similar fertilizer is recommended for use at the hills, to be supplemented on poorer soil by 200 pounds of superphosphate and from 50 to 75 pounds of potassium chloride or sulphate per acre broadcast.

Fertility practices for cigar-filler tobacco, recommended by the Ohio Station, include the liberal use of potash and phosphorus, omission of liming (on soils only slightly acid), row application of fertilizer containing fairly liberal percentages of nitrogen, phosphorus, and potash, and side dressing with a quickly available nitrogen carrier when plants have a spread of from 6 to 8 inches.

The Massachusetts Station observed that a comparatively high rate of fertilizer nitrogen is needed for growing Havana Seed tobacco of high yield and quality and that no more than one-half and probably as little as one-fourth need come from organic carriers such as cottonseed meal. The amount and distribution of rainfall during the growing season were found also to influence yield and grade of tobacco. For best results a rather high level of nitrates should be maintained in the soil during most rapid vegetative growth. The form of fertilizer nitrogen used seemed to bear little or no relation to brown root rot.

The Connecticut (State) Station found that 200 pounds of nitrogen per acre gave best results with Havana Seed tobacco where all factors of quality and yield were considered, although the optimum may lie between 200 and 250 pounds. Soybean meal as a tobacco fertilizer up to the present time has produced higher yield and better quality of Havana Seed tobacco than has cottonseed meal. These results were correlated with a higher rate of nitrification for the soybean meal.

Omission of sulphur from fertilizer for flue-cured tobacco, the Georgia Coastal Plain Station cooperating with the Department of Agriculture (B.P.I.) observed, results in a slight dwarfing and decided yellowish dappled color, unlike nitrogen starvation, the symptoms being most obvious early in the growing season and aggravated by dry weather. Tobacco responded to sulphur in amounts up to 275 pounds of sulphur trioxide per acre in accelerated growth rate, and with the heavier quantities, by early maturity and rapid ripening, but without increase in plant size. The quality of leaf did not seem to be impaired by sulphur applications. Effects on tobacco of deficiencies and excess supplies of various nutrient elements, including aluminum, boron, calcium, chlorine, copper, iron, magnesium, manganese, nitrogen, phosphorus, potassium, sodium, sulphur, and thallium, were reported by the Connecticut (State) Station from its studies over several years.

Cropping systems.—The best leaf and highest yields of tobacco, the Wisconsin Station cooperating with the Department of Agriculture (B.P.I.) has found, generally can be secured by growing tobacco continuously on the same fields for 5 to 10 years instead of changing fields often. After sod has been plowed cultivated crops should be grown for two years or longer and the land manured each year before planting the field to tobacco. Commercial fertilizers can replace part of the

manure every year or be used alone every other year broadcast at the rate of 500 pounds of 2–12–6 or 3–18–9 per acre. This system is superior to continuous culture of tobacco on the same fields for an unlimited period for it permits the fertility of all cropland on a farm to be built up, and it avoids certain dangers of rotation, such as "sod effect" and brown root rot. These practices have proved their value on hundreds of Wisconsin farms.

Good fertility practices, the Ohio Station reported, have returned profits with tobacco and also from grain and hay crops following tobacco in the rotation. Tobacco has been grown more profitably in rotation than in continuous culture and has yielded more after a legume than after corn.

The Kentucky Station finds that Burley tobacco gives best results on land kept in pasture for several years. It considers bluegrass as ideal for land to remain in grass 3 years or longer and orchard grass for shorter periods and redtop good for dark tobacco, whereas timothy should not be used in tobacco rotations. Red clover and lespedeza seem to be the best legumes to seed with grass. Two successive tobacco crops, preferably with rye or other cover between, may be grown on land in sod for 3 or 4 years.

Ragweed, horseweed, and tobacco were found desirable for tobacco rotations by the Massachusetts Station. Redtop was not so good although better than timothy or corn, which were found unsatisfactory. Conclusions were that plants containing the higher values of lignin, pentosans, high carbon : nitrogen ratios, and a subsequent low tendency to protein decomposition in soil, e. g., corn and timothy, may be suspected of being undesirable for tobacco rotation.

Oats and rye surpassed timothy in fertility maintenance of tobacco soils under cover cropping conditions at the Connecticut (State) Station. Definite evidence was obtained on the role of crop residues, organic fertilizers, and cover crops in maintaining the humus content of the soil.

Fermentation.—Micro-organisms associated with the fermentation of cigar-leaf tobacco have been isolated by the Pennsylvania Station. Selection evidently continues during fermentation and the favored types multiply profusely before the process is completed. The multiplication of an anaerobic spore-forming bacteria and cocci characterize normal fermentation. Substrate-moisture-oxygen and temperature relationships determine the nature of the microbial activities and consequently the nature of the fermentation. Unsatisfactory composition of the leaf, termed "poor quality" by the industry, favors the multiplication of fungi. Heretofore, the curing of tobacco has been prolonged and the resulting quality of the leaf very uncertain. These findings open the way for better control of the fermentation process.

Suspensions of baker's yeast, applied by the Connecticut (State) Station, to Havana Seed and shade tobacco resulted in temperature gains, better fermentation, and improved quality of leaf.

SUGAR CROPS

Sugar beets.—That sugar production by the sugar beet is influenced not only by soil, moisture, and climate, and by prevalence or absence of insects and diseases, but may also be affected greatly by differential responses of sugar-beet brands to the wide range in alti-

tude and latitude in areas where the crop is grown commercially, was reported by the Department of Agriculture (B.P.I.) in tests of brands of imported seed made cooperatively with stations in eight States. In general, tonnage-type varieties exceeded intermediate and sugar-type varieties in per acre sugar yields.

Cultural experiments by the California Station in cooperation with the Department of Agriculture (B.P.I.) with sugar beets indicated that there is no significant difference in the yield and shape of beets whether the soil is cultivated intensively to produce a fine seedbed or is stirred only to a shallow depth and weeds killed; that irrigation water penetrates shallow-cultivated seedbeds as readily as deep-cultivated ones; and that beets given only enough cultivation after planting to control weeds do not differ in yield or sugar content from those cultivated as many as six times. Sugar beets were grown successfully in hills of from one to three plants as compared with the conventional single-plant method; such planting might facilitate cross-cultivating, eliminate the need for much hand-thinning, aid in weed control, and help to combat crust formation in the rows. The desirability of longer rotation between sugar-beet crops has been shown, e. g., a 5-year rotation of alfalfa 2 years, beets 1 year, spinach and tomatoes 1 year, and another year of beets gave the highest tonnage and sugar yields.

Irrigated rotations at Scottsbluff, Nebr., in 1912–35 by the Nebraska Station and Department of Agriculture (B.P.I.) cooperating, demonstrated that farm-manure applications may be expected to more than double sugar-beet yields and increase yields of other crops in the rotations. Increasing amounts up to 30 tons a year resulted in progressively greater yields, yet the largest per-ton-values of manure accompanied lighter treatments. Excessive applications depressed both sucrose percentages and apparent purity coefficient, which, however, were not reduced by moderate and practical amounts of manure. Other rotational data in 1930–35 showed that while manures and legumes might slightly depress the sucrose percentage, their rational use is needed for satisfactory crops of sugar beets. Corn, spring wheat, oats, or potatoes evidently did not have enough influence upon sucrose percentage in available sugar per acre to indicate the choice of any of these crops to precede sugar beets.

Applications of common salt (250 to 1,000 pounds per acre) to the soil by the Michigan Station cooperating with the Department of Agriculture (B.P.I.) favorably affected the yield of sugar-beet roots, often reflected as an increase in sugar production, but had a detrimental effect upon the apparent purity coefficient of the juice and increased the total amount of ash and the proportions of sodium and chlorine.

Sugarcane.—The superiority for sirup production of the new disease-resistant varieties C. P. 29–116, bred by the Department at Canal Point, Fla., and Co. 290, imported from India, was proved in recent tests by the Department of Agriculture (B.P.I.) in cooperation with the Mississippi Station and in Georgia. These canes were expected to replace largely the disease-resistant P. O. J. 213 and C. P. 807 recommended earlier.

Sugarcane varieties variously leading in the Louisiana Station's test fields in different sections of the sugar belt included C. P. 28–19,

C. P. 29–320, Co. 290, C. P. 29–116, and Co. 281. The standard windrowing cane Co. 281 may not produce as much sugar per acre as certain others, yet suitable acreages of this variety help minimize the risks of the cold hazard. The station also reports that deep, thorough preparation of the land resulted in yield increases from 100 to 800 pounds of sugar per acre over current yields and the effect of the deep preparation endured through the second-year stubble.

Jerusalem-artichokes.—The Iowa Station finds that an acre of Jerusalem-artichokes will produce more alcohol than 2 or more acres of corn, and has obtained test runs of between 22 and 26 gallons of 95-percent alcohol per ton of fresh tubers. Certain experiments produced as high as 28.4 gallons of 95-percent alcohol per ton, nearing the theoretical yield of about 29 gallons, but the maximum yield in actual practice was expected to be about 90 percent of this figure.

SORGHUM

Station research, often in cooperation with the Department of Agriculture, has been responsible for much of the extension of sorghum growing in the Great Plains region. Sorghum, because of superior drought endurance, ability to make a crop under adverse conditions, resistance to certain insects, and adaptation to mechanical harvesting, has replaced corn in many areas, yet has its own peculiar problems.

New sorghums.—Colby milo, developed by the Kansas Station and the Department of Agriculture (B.P.I.) and released to growers, matures early, grows to a height of 26 inches, and has an erect head well extended above the leaves, and its grain will grade as yellow milo on the market. Selections of Double Dwarf Red milo resistant to *Pythium* root rot, made by the California Station, thrived in soil so badly infested with the disease that common Double Dwarf died within a month or 6 weeks after planting. Seed of this new resistant strain was to be distributed to growers in the fall of 1938. Sudan 23, a new variety of Sudan grass introduced by the California Station, proved capable of outyielding the ordinary Sudan grass now grown.

More than 20,000 pounds of a new blight-resistant milo developed by the Texas Station were distributed in 1938 to 600 farmers in 52 counties for further increase. It is noteworthy that this distribution was made within 3 years after the first commercial appearance of the disease which threatened the 45,000,000-bushel milo crop of Texas.

Sorghum production.—Practical information on growing sorghum for grain and forage, based on experiments and experience in Nebraska and elsewhere, was published by the Nebraska Station. The varietal recommendations for definite areas in the State include Early Kalo, Kalo, Sooner, Cheyenne, Greeley, Improved Coes, Day, Pink kafir, and Western Blackhull for grain; and Atlas, Leoti, Black Amber, Early Sumac, and Kansas Orange for forage.

The Missouri Station finds Pink, Red, and Sunrise kafir superior in grain yield to corn on average and less fertile land. These sorghums are also favored because of greater resistance to drought, grasshoppers, and chinch bugs.

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Sorghums have produced moderate yields even under adverse conditions in northeastern New Mexico. The New Mexico Station harvested 11.2 bushels per acre from Weskan grain sorghum with only 42 percent of normal summer rain, 5 tons of bundle feed from Leoti sorgo at high altitudes, and 11.5 bushels of Austin milo sown as an emergency crop after a severe hail.

The Utah Station cooperating with the Department of Agriculture (B.P.I.) found Sooner milo, Red Amber and Dakota Amber sorgo, Dwarf hegari, and Kalo to be dependable at Logan where the better sorghums compared favorably with standard corn varieties in total green silage. Sorghums must compete either with barley or oats for grain or with corn for silage, which limits their importance as a crop for Utah.

SOYBEANS

Many kinds of soybeans have been grown for nearly 50 centuries in the Far East and used as a high-protein and high-fat food, but only within the last 2 decades has the crop become important in the United States. Estimates were that the 6,982,000 acres sown in 1937 produced 40,997,000 bushels of beans and 4,951,000 tons of hay, and included 986,000 acres grazed or plowed under. Illinois alone harvested 22,800,000 bushels of beans, and sizable crops were also reported from Indiana, Iowa, Ohio, and North Carolina. Extensive acreages in the Southern States also were devoted to soybean hay, pasture, and green manure. The rapid extension of soybean growing in the United States may be credited in large measure to research of the experiment stations and the Department of Agriculture, especially in agronomic, feeding, and chemical problems; the American Soybean Association, an organization of growers and State and Federal research and extension workers; and more recently supplemented by activities of the United States Regional Soybean Industrial Products Laboratory, cooperative among the Department of Agriculture (B.C.&S. and B.P.I.) and stations in 12 North Central States.

Improved varieties.—A number of stations were breeding varieties for better quality of oil, more protein, and such agronomic characters as resistance to shattering.

The Hayseed soybean, developed by the Georgia Coastal Plain Station and Department of Agriculture (B.P.I.) which was released commercially in 1937, continued to be popular. Its yields of hay are around 1½ tons, or of seed 20 bushels per acre, and it has golden-yellow seed, does not shatter, and can be harvested with a combine. A dual-purpose variety, yellow-seed Virginia, capable of good yields of hay or seed of the desired yellow color, was being perfected for release by the Missouri Station. Similarly, the Mississippi Station, which already had developed the Mamloxi and Delsta varieties and the Iter Mamedo, was approaching its goal of a less shatterable Mammoth Yellow soybean. Chame, an edible soybean introduced by the Department of Agriculture (B.P.I.) and developed by the Georgia Station, is high in nutritive value and yields of seed and hay.

Production.—Practices found suitable for growing and harvesting soybeans for grain and hay have been published by several stations.

The New Jersey Station indicates Harbinsoy as the most productive grain variety and also as good for hay and green manure with ability to compete with weeds and to endure drought.

Harvesting soybeans at different stages, beginning at full-bloom, the Illinois Station obtained from later cuttings nearly twice as much hay as from earlier cuttings, although no great differences in protein content were found at the different stages. Feeding experiments with yearling heifers showed no superiority for either early-cut or late-cut hay. The proportion of the hay refused as coarse stems usually was greater in the hay cut early.

Soil nutrients.—The Missouri Station, studying the influence of magnesium on the nitrogen-fixing power and composition of soybeans, observed that a single crop may so reduce the supplies of exchangeable bases in the soil that they become th limiting factors in legume growth and in nitrogen fixation. Nitrogen fixation increased with higher levels of magnesium and higher degrees of saturation of the clay soil used with magnesium and a constant level of calcium, but did not take place at a low calcium level in the absence of magnesium. Increase in nitrogen fixation was always accompanied by increased growth.

Fertility value.—Observations and investigations by the Illinois Station indicated that soybeans should be considered a cash crop primarily and that other legumes should be grown in the rotation for soil building. Farmers report that wheat does not yield well after soybeans apparently because the seedbed is too loose and the available phosphate in soils after soybeans is low. The station found that only where the beans are used as green manure or are combined is there appreciable addition of nitrogen to the soil. Soybeans were found to remove more phosphorus and potassium than corn or wheat but not as much as did alfalfa. The bacterial population and available nitrogen in the soil were highest in the first year after soybeans and lowest the third in a rotation of corn, corn, corn, and soybeans. The Mississippi Station determined that the quantities of roots and of nitrogen left in a soil by roots of a good crop of soybeans were too small to affect the following crop materially. It noted that varieties might be grouped by root systems, as Laredo and Mamredo, which had about 9 percent of total weight and about 8 percent of total nitrogen in the roots; and Otootan, Biloxi, Delsta, Mammoth Yellow, and Tanloxi, with respective percentages of about 16 and 15 in the roots.

ALFALFA

Alfalfa was grown in 1937 in 47 States on 13,787,000 acres, which produced a total of 27,056,000 tons of hay. The greatest production was in the North Central States and under irrigation in the West. In addition, 943,900 bushels of seed were harvested. A crop so widely grown naturally has provided many problems for research, such as varietal improvement for regional adaptation, resistance to cold, bacterial wilt, and other diseases, cultural and harvest practices, and seed production.

Varieties.—Alfalfa breeding work at the Arizona Station revealed many types in commercial fields in seed-producing districts, such as plants with small to coarse stems, abundant to sparse leaves, and high

or low seed producers. The many excellent progenies isolated included a superior strain for which a source of pure seed has been established.

The survival rank of alfalfa varieties grown by the Colorado Station on irrigated land infested with bacterial wilt was for variegated strains Ladak, Meeker Baltic, Cossack, Ontario Variegated, Grimm, and Hardigan, and for common alfalfas Nebraska, Colorado, Idaho, Montana, Utah, New Mexico, Kansas, and Arizona. The two types differed little in average survival.

Fertility.—Alfalfa meadows top dressed annually with 300 pounds of potassium chloride were injured much less by winter-killing at the Massachusetts Station than those not top dressed with potash even though at seeding all meadows had received a uniform treatment of 300 pounds of potassium chloride and 600 pounds of superphosphate.

Small quantities (500 pounds) of fine limestone applied in the row by the Iowa Station greatly benefited both yield and total nitrogen content of alfalfa grown on the acid Shelby loam and Clinton silt loam. Fully limed (broadcast) Tama silt loams produced greater yields of alfalfa with higher nitrogen content and better nodulation than soils receiving limestone (one twenty-fourth, one-twelfth, and one-sixth lime requirement) in the row, all limed soils excelling untreated soils in these respects. In general, soils with a 2.2-ton lime requirement surpassed the 3.4- and 4.7-ton soils in order. Similar responses were observed in Shelby loam but total dry weight and total nitrogen content were substantially greater with inoculated alfalfa. Alfalfa on soils receiving 500 pounds in the row yielded nearly as much as on fully limed soils but contained much less total nitrogen.

A yellowed condition of alfalfa occurring on some soils in midsummer could be corrected by the North Carolina Station by adding borax. Borax applied in March relieved the abnormal condition but failed when used late in May. The yellowed condition seemed to be aggravated by liming and by liberal use of fertilizers high in soluble calcium and to be associated with abnormal infestation by certain sucking insects. The station also has definite evidence that the use of small amounts of boron may increase the resistance of crops to drought, promote the efficiency of the major plant nutrients permitting lower rates of application of fertilizer, and reduce or eliminate the adverse effects of liming.

Management.—The safest procedure for the farmer, as shown by the Michigan Station experiments, is to cut his alfalfa only twice each season. Cutting or close grazing should be avoided during the critical fall period. Alfalfa should make enough top growth in the fall to enable storage of sufficient starch in the roots as reserve to carry the plants through winter and to initiate vigorous spring growth. In Michigan most of the storage of reserve food accumulates during September. If a fall cutting of hay or fall pasturage is needed, least injury will result if alfalfa with roots well filled with food is cut or pastured late enough in the fall so that cold weather will prevent later growth and resultant depletion of root reserves. These observations were supported by findings of the Wisconsin Station where all fall-cutting treatments were harmful, but late-fall cutting after maximum food storage occurred was less detrimental to productivity and survival than fall cuttings, which reduced vegetative cover and au-

tumnal storage of reserve foods. An optimum fertility level greatly increased yields and duration compared with that on poor soil, whether cutting treatments were favorable or not to root storage, winter cover, and leafhopper damage.

Quality.—The phosphorus supply in soils and in feedstuffs is currently a question of widespread interest. Alfalfa hay grown on heavy soils, the Michigan Station reports, contained more phosphorus than hay grown on light soils. Applications of superphosphate did not change the phosphorus content of field-grown alfalfa hay but tended to increase it slightly in alfalfa leaves grown on light soil. Limestone reduced the phosphorus content and potash tended to increase it.

The total sulphur content of alfalfa, the Utah Station determined, varied with the available sulphur in the soil and was influenced by the variety, but neither seemed to affect organic sulphur content. Time of harvest was a still greater factor. French alfalfa contained the highest percentage of total sulphur and South African and Ladak alfalfas the lowest. Crude protein and organic sulphur in alfalfa were highly correlated.

CLOVERS AND OTHER LEGUMES

Clovers.—Natural wild white clover outranked common white Dutch, Ladino, and English white wild clovers in persistence and longevity when these clovers, variously fertilized, were compared by the Vermont Station for pasture purposes. Natural wild white clover succeeds best on moist, rather heavy and not too acid soils with high organic matter and mineral contents. Close grazing and repeated usage of minerals have been found important in establishing and maintaining a wild white clover pasture.

Strawberry clover (*Trifolium fragiferum*) was observed by the Washington Station, cooperating with the Department of Agriculture (B.P.I.), to make best growth with an abundance of water and low to medium salinity. It is profitable for pasture on land where the subsoil water table is too high for other crop plants, and it can endure adverse salinity until more favorable growth conditions occur.

Kentucky Selection 101, a red clover developed by the Kentucky Station, was the most productive of any tested at the New Jersey Station and survived for 3 years on relatively poor land. The Illinois Station published information on growing mammoth red clover and crimson clover.

Sweetclover.—Madrid Yellow sweetclover (strain 27474), introduced from Spain by the Department of Agriculture (B.P.I.), was found well adapted to Kansas and has been approved by the Kansas Station for distribution to farmers. Its desirable qualities include seedling vigor, frost resistance, dependable seed production, greater leafiness than varieties commonly grown, and a yield comparing favorably with common biennial white sweetclover.

Peanuts.—Practices recommended as productive and economical for growers of the large type peanut in eastern North Carolina, from the North Carolina Station's experiments, include planting hand-picked bright-colored nuts, two nuts per hill in hills 12 inches apart in a proper crop rotation on disease-free land receiving 300 pounds per acre of 2-8-4 fertilizer.

Cowpeas.—The Calva blackeye cowpea, the result of a cross between the California Blackeye and the Virginia Blackeye made by the California Station, proved resistant to *Fusarium* wilt and invaluable to growers in Stanislaus County, where the disease has been a serious problem. With single cropping, early planting, and irrigation, from 15 to 29 sacks per acre have been secured. This variety also seemed to be resistant to root knot nematodes.

GRASSES AND HAY

The remarkable expansion of grassland research at the stations in recent years is the response to current demands for better meadows and improved pastures, for soil-binding plants to help prevent erosion by wind and water and to recover areas denuded by drought and storms, for plants to replace crops in control programs, and grasses adapted to needs of dry land, poor drainage, excessive heat, high altitudes, or for sports fields. From this research several stations have published practical information on grasses and their management. For example, the Ohio Station released a bulletin on better methods of seeding meadows, the Tennessee Station a bulletin on grasses for hay and pasture and their management, and the Illinois Station popular circulars on bromegrass, orchard grass, and reed canary grass. The Kansas Station has collaborated with the State Board of Agriculture in preparing a comprehensive manual on Kansas grasses.

Timothy.—When several strains of timothy, planted in mixture with red clover, were harvested at six stages of development by the Ohio Station and the Department of Agriculture (B.P.I.), concurrent increases in hay yields and decreases in protein percentages were evident up to about the time the timothy began to mature. Harvest from about fully headed to early-bloom stages yielded the most protein per acre. More hay was produced by the early than by the medium or late selections, and more clover appeared in the mixture with late timothy.

Nitrogen fertilization in early spring increased the growth of timothy in New Jersey Station experiments but did not appreciably change its protein content at the normal time of hay harvest. Soluble nitrogen fertilizers equivalent to 125 pounds per acre of sodium nitrate applied in mid-June increased the crude protein content of hay from 6.45 to 7.74 percent in 10 days after treatment and from 5.35 to 6.74 percent in 20 days after, and the aftermath by about 50 percent. This station found Cornell 4059 timothy, a selection developed at the New York (Cornell) Station, to continuously outyield common timothy.

Bluegrass.—Moisture, fertilization, and cutting treatments were effective in the order named in determining the productivity of Kentucky bluegrass (*Poa pratensis*) in Wisconsin Station experiments. Increases due to irrigation ranged from 43.6 percent more forage without fertilizer to 125 percent more on fertilized plats irrigated weekly. Yield trends favored a 4- to 5-inch cutting level on bluegrass. Fertilizers increased the average yield of dry matter 72 percent on unirrigated land. There was a progressive decrease in yield, due to cutting, for all fertilizer and cutting treatments. The carbo-

hydrate content of rhizomes was not reduced appreciably by fertilizer or cutting on irrigated land in 1934.

Annual bluegrass (*Poa annua*) which usually begins growth in late summer or early fall, according to the New Jersey Station, makes excellent dense turf under good conditions but is not dependable, for it normally completes its life cycle in midsummer and disappears. Death may be hastened by a number of conditions. The profuse blooming and seed production that occur in all turf are largely responsible for its rapid spontaneous introduction on established sod. This bluegrass, the station finds, may be controlled by correcting poor soil aeration, soil acidity, and low fertility, and by reseeding with desirable grasses in August and September.

Sudan grass.—Factors concerned in the formation of a high content of hydrocyanic acid in Sudan grass, a potential danger to livestock and a drawback to this good pasture grass, have been studied by the Colorado, Minnesota, South Dakota, Wisconsin, and other stations. Work of the Colorado Station indicates that the material differences in hydrocyanic acid production by inbred lines of Sudan grass are heritable. Its production in inbred lines seemed to be influenced by seasonal conditions and soil differences, as in amount of available nitrogen and time of its application. The Minnesota Station has also reported on variations in hydrocyanic acid content of Sudan grass plants. The management of Sudan grass for control of cyanide poisoning, based on studies at the Wisconsin Station, is discussed elsewhere in this report.

High-altitude grasses.—Bromegrass, orchard grass, and crested wheatgrass were the most promising grasses tested by the Colorado Station for 10 years on dry land at high altitudes. Bromegrass gained in stand and forage throughout the test, predominated at the end, and outyielded orchard grass, which was more consistent. Crested wheatgrass made good yields from pure plantings when established. Yellow sweetclover, the most promising clover, returned good yields in the first few years but did not persist. A mixture suggested for dry-land conditions similar to those at Fort Lewis includes bromegrass 10 pounds, orchard grass 8, crested wheatgrass 8, and yellow sweetclover 4 pounds.

Drought resistance.—Artificial drought tests of hay and pasture grasses and legumes in sod and seedling stages of growth by the Minnesota Station gave results in harmony with those obtained under field conditions. Crested wheatgrass and bromegrass were most drought resistant in both tests, and alfalfa was most drought resistant among the legumes. Such artificial tests thus may indicate species or varieties of forages which can be expected to thrive under natural drought conditions.

New grasses.—Two grasses developed by the Oregon Station, in cooperation with the Department of Agriculture (B.P.I.) and now in commercial production, are Superior reed canary grass and tall fescue. Superior reed canary grass is adapted to wet-land conditions but also grows satisfactorily on land too dry for ordinary reed canary grass and is taller, slightly later, leafier, larger seeded, and less inclined to seed shattering. Tall fescue closely resembles meadow fescue but is a long-lived perennial that grows from early spring to late

fall and in mild climates through winter. While tall fescue is chiefly a pasture grass producing rather coarse but very palatable forage, it can be used for hay.

Tift Bermuda grass, in studies by the Georgia Coastal Plain Station and Department of Agriculture (B.P.I.), demonstrated its value by yielding around 1¾ tons of hay from two cuttings after weeds and crabgrass had been removed. This grass has large root stocks or rhizomes and is one of the hardiest and most aggressive types of Bermuda grass tested. It might become a serious pest if allowed to start in cultivated fields.

The Florida Station and the Department of Agriculture (B.P.I.) have developed several improved strains of Napier grass which are highly resistant to eyespot (*Helminthosporium ocellum*).

Seed production.—In certain sections of the United States production of forage-crop seeds has become a major enterprise. The Oregon Station reports that its State's $4,500,000 seed industry has been developed and stabilized by the introduction, in cooperation with the Department of Agriculture (B.P.I.), of such new forage seed crops as tall fescue, meadow foxtail, Highland bent, strains of English ryegrass, and strains of rot-resistant crimson clover, and hardy strains of red clover.

Seed yields obtained in Idaho Station experiments showed that production of seed of smooth bromegrass, crested wheatgrass, slender wheatgrass, and meadow fescue offers distinct advantages to the producer who wants to increase his grass acreage and also grow a cash crop. From 6 to 8 pounds of seed per acre were found enough for good stands. Likewise, hay yields were as large with these rates as with heavier seedings.

A demand for information on methods of harvesting seed of native grasses was reported by the Kansas Station. The type of combine with a rasp form of cylinder successfully harvested seed of little bluestem and of the side oat and blue grama grasses. The seed usually was threshed clean enough for planting without recleaning. This method could also be used in harvesting seed of hairy grama grass.

WEED CONTROL

Weeds cost American farmers millions of dollars every year by lowering the yields of economic crops, reducing the market quality of grains, wool, and other farm products, poisoning livestock, serving as hosts for diseases and insect pests, and depressing the value of cultivated and pasture land. A problem of this magnitude naturally has received the attention of the stations, the Department of Agriculture, and other agencies, and many practical control measures have resulted from station research. Several stations, particularly those in California, Illinois, Kansas, Montana, North Dakota, and South Dakota, cooperated during the year with other agencies in publications on weed control. Current investigations pay special attention to the life history and growth habits of weed plants, their physiology and anatomy, and control by cultivation, crop rotation, grazing, and chemical methods.

Bindweed.—That bindweed could be eradicated by tillage under ordinary Nebraska field conditions for about $10 per acre was indicated by field-scale experiments of the Nebraska Station and the Department of Agriculture (B.P.I.) cooperating. With standard tillage equipment the total cost per acre per cultivation ranged from 32 to 34 cents. Two years of clean cultivation eliminated from 95 to 100 percent of the original stand of bindweed, yet supplementary treatment was needed to complete eradication.

Clean cultivation continuously or in combination with a smother crop was found by the Kansas Station and the Department of Agriculture (B.P.I.), working in western Kansas, to be the most dependable and economical way to destroy bindweed where tillage implements can be used. Cultivation for 1 year and part of a second has killed bindweed at a cost of only one-sixth to one-fourth that of chemical treatments. Where clean cultivation is impracticable, treatment with sodium chlorate proved most satisfactory for eradicating bindweed. The dry salt is applied by hand or a fertilizer distributor at the rate of 3 or 4 pounds per square rod (about 500 to 600 pounds per acre) between September 1 and the first killing frost, and if spread on a cultivated field should be disked or harrowed into the soil to prevent loss. The reduced fire hazard and convenience of a single heavy application without spray equipment was expected to result in wide use of this method.

Cultivation for a single season of land heavily infested with bindweed, the Colorado Station reports, doubled the yields of wheat, rye, and corn in the following year as compared to untreated land, and the increased yields more than paid for the cultivation and the crop omitted during cultivation. The use of weed burners gave no better results than one shallow cultivation and cost more.

The Colorado and Idaho Stations observed that cultivation continued for about two seasons practically exhausted the root reserves in bindweed. The Idaho Station has used carbon bisulphide successfully for control in small areas of bindweed and other perennials including Russian knapweed, whitetop, Canada thistle, leafy spurge, and perennial sow thistle. On land clean of vegetation and moist to the surface, 2 ounces of the activated material is placed in holes 6 to 8 inches deep in staggered 18-inch rows—about 2 gallons per square rod—and tamped after application. Reinfestation is prevented by digging out surface growth and shallow cultivation to kill seedlings.

Downy bromegrass.—Downy bromegrass (*Bromus tectorum*), often called wild oats in Michigan, spreads rapidly in alfalfa fields, fence rows, and waste places, especially on sandy soil, and there seem to be no well-established methods except clean cultivation for its control. Several measures used with some degree of success by the Michigan Station, but each with limitations and draw-backs, include spring grazing, use of alfalfa-grass mixtures and alfalfa-cutting management, cultivation before and after growth starts, early cutting of alfalfa, and fall cultivation.

Leafy spurge.—Sodium chlorate proved to be the most effective herbicide tested by the Iowa Station for the control of leafy spurge (*Euphorbia esula*), the indicated spray formula including sodium

chlorate 1 pound, animal glue 4 grams, sulphuric acid 3 cubic centimeters, and water 1 gallon. Best results came from spraying actively growing plants in full foliage or about to bloom. Later treatments might be needed to complete eradication. Well-rotted manure (3 tons to the square rod) was also effective against leafy spurge, and plowing deeply in the fall and again in the spring materially reduced the amount of the weed. Alfalfa is a good crop to use on land where leafy spurge has been killed with sodium chlorate. The North Dakota Station demonstrated that sheep would eat leafy spurge in a pasture in mixture with bluegrass without harmful effects and thus keep it under control.

Nutgrass.—Plowing or disking at intervals of 3 weeks or less during two consecutive growing seasons by the Alabama Station completely eradicated nutgrass on Norfolk sandy loam soil, the infestation being reduced about 80 percent in the first year.

St. Johnswort.—For control of St. Johnswort in pasture, the California Station found that soil treatments were the most reliable and effective type of chemical application and that sodium chlorate, borax, and mixtures of borax and sodium chlorate were effective either as dry salt or as sprays. The borate ores—colemanite and Kramer ore—were effective when applied dry, alone, or combined with sodium chlorate. Mixtures of 4 pounds of either colemanite or Kramer ore with 0.5 pound of sodium chlorate per square rod, equivalent to 720 pounds of mixture per acre, costing about $14.40, were the most satisfactory in cost and ease of application. The mixtures cost slightly more than straight dry sodium chlorate but were applied more easily and had lower fire hazards and a greater residual effect against St. Johnswort seedlings.

Weeds in onions.—The New York (Cornell) Station reported that a 10-percent solution of sulphuric acid applied as a spray proved quite effective in killing purslane and certain other annual weeds in onions without permanent injury to the crop.

Pasture weeds.—Renovation of bluegrass pastures by the Wisconsin Station, working in western Wisconsin, by the establishment of alfalfa, sweetclover, and red clover in thinned sods without plowing had greatly reduced the weed population 2 or 3 years later, especially ragweeds and horseweed.

Lawn weeds.—Applied to Bermuda grass lawns in winter by the Alabama Station, calcium cyanamide was very beneficial in removal of annual weeds and in the stimulation from the nitrogen it supplied which continued throughout the summer. Preferably the granular form should be applied in January or early February at rates of from 1,000 to 2,000 pounds per acre with the weeds either wet or dry. The station warns that cyanamide treatment should be limited to Bermuda grass lawns and should not be applied to bluegrass or other lawns or near ornamentals.

Mercurated ethyl stearate, found to be an efficient herbicide by the Illinois Station and superior to iron sulphate, copper nitrate, and ammophos, could kill dandelions, plantains, and crabgrass in lawns if sprayed under proper conditions. Indicated practices include a concentration of 3 cubic centimeters per liter, using kerosene or one of its fractions as a solvent, and applying in summer rather than in spring

or fall preferably in late afternoon and evening and on areas with the grass and weeds cut short.

Control measures indicated for crabgrass in the lawn by the Minnesota Station include a heavy bluegrass stand, pulling out young crabgrass by hand, mowing and fertilizing, free use of ammonium sulphate, and spraying with sodium chlorate solution.

Dandelions were controlled in bluegrass-white clover lawns at the Iowa Station by spraying undiluted kerosene with a boiling-point range of from 180° to 250° C. and an unsaturated hydrocarbon content of not over 4 percent, uniformly over the lawn during cool, cloudy weather at the rate of 200 gallons per acre, preferably 2 months before the end of the bluegrass-growing season.

Studying the life history and ecology of buckhorn plantain, the Ohio Station showed that this serious lawn pest is a short-lived perennial, dying in from 2 to 4 years and less resistant to cold than bluegrass. Consequently, it may be eliminated from lawns by cutting often to prevent seed formation.

Weeds as cover crops.—Of a number of weeds common to Florida, analyzed by the Florida Station, boerhaavia, coffeeweed, carelessweed, and crabgrass contained rather high percentages of water-soluble and total nitrogen, and appeared suitable for cover-crop purposes where a rapidly nitrifying material is needed. Wire grass, peppergrass, sandbur, Spanish-needles, and ragweed were low in nitrogen and slow to yield available nitrates.

Herbicides.—Investigation on 80 soils by the California Station, cooperating with the Department of Agriculture (B.P.I.), showed that higher concentrations of sodium chlorate are needed on fertile than on less fertile soils. Some other method ordinarily should be used in very fertile or very saline soils where chlorates are not highly successful. Arsenic toxicity, on the other hand, varies with soil texture rather than fertility, and definite recommendations were made for arsenic trioxide and sodium arsenite dosages on different soil textures. Arsenicals, especially dry white arsenic, proved successful where all vegetation is to be held in check for a long period. A distributor for applying dry white arsenic, designed and built at the station, has been adopted for making sterilized backfire strips in national forests. Sulphuric acid was used successfully as a selective spray for control of mustard, radish, and other broad-leaved annual weeds in grainfields. About 12,000 acres of cereals were sprayed in 1938, and the acreage so treated is increasing rapidly in California. A specially designed power spray rig eliminates some of the difficulties in applying sulphuric acid.

PASTURES AND RANGES

Pasture and range research is concerned with the welfare of those who utilize a large area of our country in the grazing of livestock. At this time accumulated knowledge and active research are contributing information essential for appropriate changes in land use and conservation.

Pasture and range research has recognized differences in ecological and biological conditions of the many agricultural areas of the country which are favorable or unfavorable to grassland production. It

has also taken into account the importance of grassland management suited to the ecological areas. Phases of research are designed to meet the requirements for more intensive land use, while others deal with problems peculiar to natural grazing lands which are more extensive in nature.

Toward these objectives the research personnel of the State stations and the Department of Agriculture are integrated and directed through cooperative agreements and conferences for the consideration of research progress and planning.

Progress of pasture and range research has been accelerated in recent years by marked improvements in the technique of measuring the economic value of species and the response to management practices.

The Florida Station has recently completed an important series of experiments dealing with the physiology and growth behavior of pasture plants which furnish a practical guide for economical fertilization and rate of grazing. Cooperative studies between this station and the Department of Agriculture (B.P.I.) show progress in the selection of legumes and grasses better suited to pasture areas of the State and the southeastern coastal region.

The South Carolina Station reports studies of the influence of lime and fertilizers upon the yield and mineral content of carpet grass grown on Coxville sandy loam, a soil naturally deficient in minerals. All minerals were relatively low on the unfertilized pastures in this area of the State, the mineral content of the herbage often being too low for adequate nutrition of the animals. Liming increased both the calcium and magnesium content of the carpet grass clippings, and the addition of superphosphate resulted in a marked increase in phosphorus and a perceptible increase in the calcium content of the grass.

A progress report of cooperative work of the Wisconsin Station and the Department of Agriculture (B.P.I.) on methods used in botanical analysis of pasture vegetation indicates that the two point-quadrant methods are best for rapid and reliable means of determining pasture composition and relative productivity. The inclined point-quadrant method was found to cover larger areas per reading and to be better adapted to the study of tall vegetation.

Studies of pasture grasses individually and in mixtures at the Illinois Station indicate that bromegrass will become an important new grass in the State because of its persistence under heavy grazing, high carrying capacity, length of effective grazing period, and resistance to drought. Results from studies of chemical composition, apparent digestibility, and rate of consumption of various pasture grasses help to interpret the results of more practical grazing tests and point to more profitable systems of pasture management.

In a study of climatic conditions, soil type, topography, soil moisture, salt concentration, and pasture management in relation to associated grass species, the North Dakota Station finds that the grama-needlegrass-sedge type of vegetation has apparently reached the highest degree of stabilization in relation to climate, and the soil of this type most nearly approaches the typical profile of the dark brown soils. The big bluestem type seems to depend upon moisture

in addition to that received from precipitation. The other vegetation types appear to be successional stages following erosion, deposition, salinization, or cultivation.

A survey of existing range conditions by the Colorado Station indicates a sufficient population of blue grama and buffalo grasses to permit a decided improvement in density of these palatable grasses under a system of improved range management and better rainfall conditions. The annual bromegrasses and filaree which appear to be gradually crowding out the native perennials in certain range areas were reported by the Nevada Station to be generally acceptable types of range plants.

Grazing studies initiated by the Kansas Station in 1916 to establish management methods which would maintain the grazing value of extensive bluestem pastures have resulted in the following valuable conclusions: By deferring grazing until June 15 each year, the carrying capacity per acre was increased about 25 percent and the increase in gains by livestock was 33 percent. In their leafy stages the bluestem grasses were found to contain adequate crude protein and mineral for nutritional requirements and satisfactory gains.

In a study of seasonal changes in the composition of range grasses, the Arizona Station found moisture, crude protein, and phosphorus high in young plants, decreasing to a minimum as the plants became mature. The changes in composition of range grasses were correlated with the increase and decrease of weight in grazing cattle.

The West Virginia Station, cooperating with the Department of Agriculture (B.P.I.), reports marked increase in the number of pasture days and comparable gains in animal weight resulting from applications of lime and phosphates to lands that have sufficient topsoil to maintain bluegrass and white clover. Studies of the DeKalb soils indicated that the neutralizing effect of lime had lasted 13 years.

Research has been effectively applied to the improvement of pasture and range grasses and clovers which withstand unfavorable conditions and furnish extended grazing periods of more palatable herbage. Through hybridization of Mosida (winter wheat) × *Elymus condensatus* and selection, the Idaho Station has produced a new grass which combines the hardiness and productivity of the wild ryegrass and the palatability of the Mosida wheat parent.

Pasture studies of the New York (Cornell) Station have shown that wild white clover (*Trifolium repens*) when added to bluegrass pasture increases the yield and uniformity of sod, adds to the protein content of the herbage, increases the nitrogen content of the soil, and reduces erosion.

The value of pasture sod for the use and restoration of abandoned land has been demonstrated in studies of the Arkansas Station. Coastal-plain soil depleted by cropping and soil erosion was converted to Bermuda grass and legume pasture. Fertilizer treatment and good management have increased the productive power of this pasture from 150 to 440 pounds of beef per acre during a period of 4 years. Similar studies were conducted with Lintonia silt loam soil, which resulted in a change from 150 pounds of beef per acre to 589 pounds in 6 years of this treatment. No other system of crop rotation and fertilization has resulted in such marked soil reclamation.

HORTICULTURE AND FORESTRY

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That horticultural research may have a very direct bearing on everyday life is brought out effectively in the address of the retiring president of the American Society for Horticultural Science, December 1937, from which the following is taken:

> In thus dealing with plant life, the horticultural scientist remains conscious of the fact that his studies are directly concerned with the means that contribute to the health, the enjoyment, and the economic well-being of a large part of our population.

Whether it is to help the grower increase his income or to develop more beautiful plants with which to adorn the home, the objectives are equally worthy and cannot in any event be entirely disassociated. Even the most basic type of investigation has an ultimate purpose in the betterment of everyday life, though for the time being such objective may be concealed in the technical features of the problem.

The difficulty of setting apart annual accomplishments from long-time studies is apparent to the thoughtful observer, yet it is evident from the numerous progress reports presented each year in the Proceedings of the American Society for Horticultural Science and from the many bulletins and papers prepared by horticultural workers that each year does produce a fruitful addition to the general fund of knowledge. The changes from year to year in trends of horticultural research are obviously not sharply marked, but there is a constant and growing tendency to go more deeply into the problems and not to be satisfied with superficial observations of facts.

FRUITS AND NUTS

New and better fruits.—The Minnesota Station urged the more thorough testing of new productions before dissemination to the growers, stressing the fact that such care is needed to maintain the high degree of appreciation for station fruit breeders now entertained by fruit growers and nurserymen.

That the experiment stations are not overlooking new scientific developments in the field of genetics is indicated in the work of the New York State Station with colchicine, a drug that inhibits nuclear division but permits chromosome splitting. Doubling of chromosome number was secured in the marigold, tomato, petunia, snapdragon, and certain other species, and it appeared altogether likely that the new technique could be profitably extended to certain fruits.

Stimulated by a need of strawberry varieties that can survive the hot, dry summers of the Southwest, the Texas Station developed a number of promising new seedlings, two of which, designated as Texas 21 and Texas 68, are described as superior to Klondike and Missionary, the present leaders among commercial sorts. Texas 68 combines early fruiting, late runner formation, abundant foliage, and high berry color, with desirable shipping qualities. Texas 21 is considered a very promising home-garden variety.

Three promising new strawberries developed in the breeding program of the Connecticut (State) Station were selected from among thousands as promising for general culture. Two were outstanding because of attractive fruits, and the third because of high productivity.

A new peach, J. H. Hale×Kalamazoo, originated by the Michigan Station, was found very promising and was introduced to growers under the name of Kalhaven. The fruits were said to be of high quality, good shipping character, and were a week earlier than Elberta. Indicative of the high merit of the new varieties of peaches bred by the New Jersey Station, it is interesting to note that two, Golden Jubilee, and Golden East, were among the five leading New Jersey commercial varieties in the 1937 season.

Two new varieties of red raspberries, namely, Washington, from a cross of Cuthbert and Lloyd George, and Tahoma, from a cross of Lloyd George by Latham, were introduced by the Washington Station. These varieties are said to be well adapted to the region west of the Cascade Mountains, where Cuthbert and some other presumably hardy kinds suffer injury due to the mild winters which do not prolong the rest period sufficiently.

As a background to a more effective breeding program, the Hawaii Station observed from a series of controlled crosses that sex in the papaya is determined, apparently, by a multiple allelomorphic series of factors. Males and perfect-flowered forms are heterozygous in nature, while the females are homozygous and recessive.

Improved cultural methods.—Observing that fruit trees set directly in locations from which old trees had been removed often made very poor growth, the Idaho Station conducted a study in which young apple, peach, sweet cherry, apricot, and prune trees were set in the old holes and in the center of the squares. In all cases, the trees in the new soil made the better growth. Applications of farmyard manure favored recovery in the old sites. Analyses of the soil showed a measurable amount of soluble arsenic in the old spots and only a trace in the new, but whether this was a factor in the failure to grow readily was not established. Notes on vegetables planted on old orchard sites showed also a distinctly poorer growth where the vegetable rows passed over the sites of former trees. In addition to soluble arsenic, poor physical condition of the soil and depletion of nutrients are suspected causes of poor growth.

Root development of young Delicious apple trees, interplanted with corn at 3.5, 5, and 7 feet from the tree row, was found by the Nebraska Station to be materially influenced by the corn. The smallest tree-root systems were nearest the corn. The depth of root penetration was similar in all three plats, but the nearer the corn, the more deep roots. Trees mulched with straw made the most extensive root devel-

opment of any lot the first growing season. In the second season, trees under mulch made a lateral development of approximately 10 feet, as compared with 7.5 feet for clean culture. Measurements showed that apple roots make considerable development while the tops are dormant.

As determined in experiments conducted by the California Station, French prunes supplied with water whenever moisture was reduced to 15 percent in the upper 3 feet of soil (about 3.3 percent above the permanent wilting percentage) yielded approximately the same results over a 5-year period as did comparable trees irrigated whenever the moisture reached the permanent wilting point. Returns were also approximately the same, indicative of comparable quality. Similar results were secured with Persian or English walnuts.

Results of experiments with Howard 17 and Dorsett strawberries led the Rhode Island Station to conclude that from 6- to 7-inch spacing is apparently most desirable with respect to yield.

Differential fertilizer treatments applied by the Colorado Station in a mature Montmorency cherry orchard near Fort Collins indicated that nitrogen alone was the most effective treatment in increasing yields. A residual effect on the manured plats suggested the possibility that manure might ultimately equal or surpass the nitrogen treatment. Yield increases appeared due to an increase in the number of fruits, and not their size.

In connection with a cover-crop experiment in a Purdue University apple orchard, determinations of total nitrogen in the several plats in 1914 and 1937 showed that none of the cover crops had maintained the nitrogen content of the soil. The reason that the soybean and crimson clover failed is ascribed to poor growth of the covers after the apple trees had matured.

Cyanamid was safely applied by the Michigan Station to apple, pear, and plum trees, both in the fall and the very early spring. In the case of the cherry and peach, Cyanamid proved satisfactory in fall but not in spring, when leaf burning and sometimes defoliation occurred, particularly in dry seasons.

Comparisons at the Missouri Station of sulphate of ammonia, nitrate of soda, and Cyanamid as sources of nitrogen for apple trees showed little difference in growth or in nitrogen recovery from the soil from the three materials under favorable climatic and soil-moisture conditions, leading to the general conclusion that the Cyanamid, properly used, was as satisfactory as the other two materials. Fall applications of all three fertilizers gave equally good if not better results than did spring applications.

That potassium does not stay fixed where applied but may move downward in the soil was indicated in studies carried on by the New Hampshire Station in four commercial orchards operated on the mulch system. In one soil, potassium was recovered in the 6- to 8-inch layer. Evidence that the trees were obtaining the applied potassium was indicated in a higher potassium content in the leaf petioles of the potassium-treated trees.

Further insight on the movement of potash in mulched orchard soils was revealed at the Ohio Station in an orchard where potassium as a whole was found very low and where, in the unmulched area, applied potassium failed to move downward into the root zone; very large contents of potassium were found to a depth of from 24 to

32 inches or more beneath a 38-year-old mulch. In no case had potassium fertilizers been applied to the mulched trees. The same condition was found in a nearby orchard where mulch had been applied to part of the area for 22 years. The soil beneath two mulched trees had a content of 1,000 pounds per acre of available potassium to a depth of 2 feet, while 40 feet distant under clean cultivation there was less than 175 pounds of potassium to a 2-foot depth.

Two instances of potash deficiency were noted by the Pennsylvania Station in commercial peach orchards. Both responded favorably to potash fertilization. It was interesting to note that a row of trees fertilized with barnyard manure failed to show any potash deficiency.

Intensive study by the Connecticut (State) Station of the soils in 12 commercial apple orchards revealed wide variation in physical and chemical properties. Seven orchards, the soil of which ranged from pH 4.26 to 4.93, had an abnormally low phosphorus availability. Five of the orchard soils were markedly low in potash.

Noting an early decline of citrus trees in the Rio Grande Valley, the Texas Station applied various fertilizer and soil amendments with a view to correcting the situation. The beneficial effects of four annual applications of a 10–30–10 fertilizer were outstanding, and annual applications of ground sulphur were also helpful. Spraying with combinations of iron, manganese, zinc, and copper gave temporary improvement, all of which led the station to conclude that increased salinity and alkalinity were primary causes of the decline and that citrus should be planted on soils where subsoil drainage is possible.

The value of legume cover crops for the pecan was indicated in studies by the Florida Station, where combined summer and winter covers of legumes greatly increased returns at a net cost much below that attained by the use of commercial fertilizers. Winter cover crops had the advantage of growing during the period when there were no leaves on the trees.

Lead arsenate spray residues may have a toxic effect in the soil sufficient to prevent crop growth 5 years after the apple trees are removed, according to observations by the Washington Station. Ferric sulphite in large amounts was found to reduce the detrimental effects of the soluble arsenic compounds, apparently by direct absorption and by antagonistic effect.

Propagation.—According to the New York State Station, considerable interest was shown by commercial growers in dwarfing stocks for the apple, particularly in semistandard trees that would come into bearing early and be much more adaptable to pruning, spraying, harvesting, and other orchard operations.

Studies conducted by the Kentucky Station failed to show any significant difference in either height or diameter growth during the first growing season, whether apple trees were worked on whole or piece roots. Mortality was, however, considerably greater in the case of the piece roots. Equally good results followed the use of tip or basal half of the scion.

As a result of propagation tests and microscopic examination of various tissues of the apple tree, the Iowa Station concluded that there are two distinct growth phases in the apple, characterized as juvenile and mature. The juvenile growth was produced from ad-

ventitious buds on the roots of older trees, and also possibly from adventitious buds on the branches of certain varieties. Stem cuttings of juvenile shoots rooted readily, whereas cuttings of mature wood were very difficult to propagate without special treatments. The juvenile phase was distinguished by thinness of the leaves, small amount of pubescence, and the abundant production of anthocyanin in the shoots.

Observations by the Indiana Station on the yields of Grimes Golden apple trees worked on several different rootstocks showed own-rooted Virginia crab to be outstandingly superior with respect to total yield and size of individual fruits. A possible explanation of this superiority may lie in the fact that the leaves of the Virginia crab-root trees were heaviest, being 50 percent greater than those on French crab, the lightest of the rootstocks under comparison.

That the use of synthetic growth-promoting substances in rooting softwood cuttings of deciduous fruits, such as the apple, pear, and cherry, has limitations was indicated in extensive trials by the New York State Station. It was apparent that different species and varieties within a species respond differently and that the inherent capacity of a plant to root is a factor.

Tests by the Florida Station of the effect of a commercial root-growth-promoting substance on a large number of semitropical plants gave generally promising results. Among plants failing to root were the persimmon, black walnut, and pecan. On the other hand, many species that would not root normally did root when treated. The chemical hastened rooting, increased the percentage of success, and promoted a more substantial root system.

Comparing rough lemon and sour orange as rootstocks for oranges, tangerines, and grapefruit, the Florida Station found all three much more fruitful on the rough lemon. On the other hand, fruit of the trees on sour orange roots was of better quality as to flavor and texture, and following the 1934 freeze, the trees on sour orange suffered less injury. The much greater production of the trees on rough lemon gave them a significant advantage. Observations by the California Station on Eureka and Lisbon lemon trees growing on sweet orange, grapefruit, rough lemon, and sour orange rootstocks showed marked differences in varietal response. The Eureka lemon showed a distinct preference for the sweet orange, whereas with the Lisbon lemon there were no significant differences.

Notable progress was reported by the Hawaii Station in the propagation of several tropical species such as litchi and macadamia. Ringing was employed to increase the carbohydrate reserves of the scion and growth-promoting substances to facilitate callus formation and union of the grafted tissues.

Physiological studies.—The uniform distribution of soil moisture at comparable depths in a young peach, prune, and walnut orchard was associated by the California Station with a uniform distribution of roots, and it was concluded that in such an orchard sampling of the soil during the growing season should provide a basis for an effective irrigation schedule. However, in an orchard where root distribution was not uniform, measures of relative wetness would not aid irrigation practice.

Observations by the California Station on the growth of Washington Navel and Valencia orange trees supplied with nutrient solutions of known pH values showed rotting of the roots when the pH remained close to 8.1, even when abundant air was forced through the nutrient solutions. A restoration of vigorous growth from the living portions of the root system followed the addition of acid to the cultural solutions.

Based on long-continued observations in citrus orchards, the California Station reported that 55° F. is about the lowest temperature at which growth occurs. Apparently the optimum temperature range for the sweet orange is approximately from 73.5° to 91.5°. Early spring temperatures, rather than day length, are believed the important factors in determining the time of bloom of the Washington Navel orange in California.

Appreciable reduction in photosynthetic activity for a few days following the application of 1–40 lime-sulphur spray to a young Baldwin apple tree growing in the orchard of Cornell University led to the practical conclusion that other materials such as the wettable sulphurs might advisably be used instead of lime-sulphur to control fungus diseases.

At the approximate time of flowering, three large branches on Minkler and Arkansas apple trees were ringed by the Missouri Station by the removal of ¼-inch strips of bark. The large increase in fruit in some of the treatments indicated that ringing had reduced the drop, especially the second, third, and fourth. Since the seed number was not altered significantly, the station concluded that ringing had little influence on fertilization of the ovules. As determined by the California Station, the removal of a ring of bark during approximately the first half of the blossoming period of certain branches on Fuerte avocado trees greatly increased production as compared with adjacent untreated branches. Later ringing had no beneficial effects. Regirdling the limbs the next season had a beneficial influence on yield but to a lesser extent than the initial treatment.

Slight differences observed by the Oklahoma Station in the chlorophyll, carotene, and xanthophyll content of the leaves of Concord as compared with other grape varieties were not sufficient to explain the frequent failure of the Concord fruit to color evenly. On the other hand, Concord leaves were considerably higher in total solids, a fact which, associated with the lower solids content of Concord berries, may throw light on the problem.

Observations by the California Station on irrigated Washington Navel oranges budded on sweet orange showed three distinct cycles of radial growth, starting in early April, early July, and early August, respectively. The cycles of shoot elongation and cambial growth showed a strong tendency to alternate, with shoot development coming first. There were, however, only two distinct cycles of root elongation from March 1 to October 1, the first coinciding rather closely with the first cycle of cambial activity.

None of several treatments, including fertilizing, root pruning, or application of molasses to the soil, investigated by the Louisiana Station as a possible means of increasing the resistance of the Satsuma orange to low temperature, proved to have any marked effect on

dormancy. The conclusion was made that Satsuma oranges should not be planted in regions of frequent killing frosts, unless orchard heating is possible.

Anatomical studies by the Maine Station of apple tissues injured by low temperature indicated that death of certain cells followed by the closing of conducting vessels with a gumlike substance is the primary cause of death. In no case was the dormant cambium found injured, even at temperatures lower than ever occur in the orchard.

As a result of many years' study of the pollination requirements of cultivated grapes, the New York State Station reported considerable self-unfruitfulness in certain varieties. A hybrid variety, known as Aramon × Ruprestris Ganzin No. 1, was found an excellent source of pollen which when collected and mixed with lycopodium powder was very effective in increasing production in other varieties. Eumelan, a valuable wine grape, produced 50 percent more fruit when pollinated artificially than when left to open pollination by natural agencies.

That none of the named varieties of blueberries is sufficiently self-fruitful to set a commercial crop was indicated in studies of the Massachusetts Station in which the plants were covered to exclude insects. There was, however, considerable difference between varieties with respect to self-fruitfulness.

As reported by the experiment station of the University of Puerto Rico, coffee trees made their best development under one-third and one-half full sunlight and less satisfactory growth with two-thirds full sunlight. In the case of 7-year-old trees in Coloso clay, 94 percent of the roots were found in the upper foot of soil, this being attributed to the high percentage of organic matter in this zone. On Catalina clay, the Columnaris variety outyielded the Puerto Rico by 600 pounds of marketable coffee per acre. Root-promoting substances failed to stimulate root formation in coffee cuttings.

Fruit thinning.—A differential response of apple varieties was observed by the New Jersey Station in thinning studies with Stayman Winesap, Rome Beauty, Grimes Golden, and other well-known varieties. Apparently, Stayman Winesap was less able than Rome Beauty or Grimes Golden to compensate by size increase for the reduction due to decreased numbers. Blossom thinning of Wealthy apples so that the remaining spurs were from 10 to 12 inches apart resulted in good crops the current and succeeding year, indicating that blossom thinning is more potent in effect on the next crop than is fruit thinning.

Utilizing the opposite halves of the same trees of Delicious, Northern Spy, Oldenburg, and Stayman Winesap, the Ohio Station observed that thinning 3 weeks after petal fall resulted in the production of sufficient flower buds to yield a commercial crop the next year. On the other hand, delayed thinning from 6 to 7 weeks after petal fall was associated with a very marked reduction in fruiting the following year. The difficulty of early thinning presents, however, an obvious practical difficulty.

The higher weight of individual peaches following systematic thinning of the fruit was attributed by the North Carolina Station to be largely the result of removing the inherently smaller individuals rather than to a direct stimulation of the thinning process.

Fruit storage.—Stating that the need of light for coloring apples has been stressed so urgently that the mistake is often made of exposing detached fruit to the direct rays of the sun, the New York (Cornell) Station reported in investigations with McIntosh apples that the largest amount and the most desirable type of color development occurred in those fruits where three layers of cheesecloth were suspended 18 inches above the fruit. A location beneath a large, low-headed tree is considered ideal for improving the color of harvested apples. Conditions were still further improved where the fruit was placed on a poultry-netting frame 18 inches above the soil and underlaid with white cloth for reflecting the light upward.

As a result of studies with freshly picked red raspberries and strawberries stored in atmospheres containing largely increased percentages of carbon dioxide, the Minnesota Station concluded that such treatment aids in retaining attractiveness, reduces spoilage, and lengthens the time that the fruits can be held in marketable condition.

Evidence was secured by the Oregon Station in studies with pears treated with ethylene while still containing starch that the softening changes following ethylene treatment are essentially chemical rather than physical in nature. The treated pears contained more reducing and total sugars and less starch than did comparable untreated fruit. Ethylene apparently accelerated the rate of pectic changes in the cell walls.

In the storage chambers of the New York (Cornell) Station modification of the atmosphere to contain 5 percent of carbon dioxide and 2.5 percent of oxygen enabled McIntosh apples to keep longer and in better condition at 40° F. than at lower temperatures in ordinary air. Northwestern Greenings kept in marketable condition until the middle of May in the modified atmosphere, as compared with the middle of January in ordinary air.

Studies by the California Station with Yellow Newtown apples and Bartlett and Hardy pears indicated that with an increase in carbon dioxide in the storage atmosphere, fruit would keep in as good condition at 45° F. as was possible in ordinary air at from 32° to 36° F. In airtight cabinets where the carbon dioxide was increased by the output from the fruit and the oxygen concentration lessened by respiration, essentially the same effects were secured as in artificial atmospheres.

Although modifications of the composition of the storage atmosphere helped to preserve citrus fruits in some cases, the Florida Station reported serious effects on flavor. Both taste and texture of grapefruit were affected detrimentally by high concentrations of carbon dioxide and oxygen. Fruits stored in nitrogen developed a musty, disagreeable flavor though retaining bright color and firmness. Carbon dioxide in excess resulted in a soggy condition. Still-air storage, low in oxygen and carbon dioxide and high in relative humidity, favored long keeping in good condition.

Considerable progress was made by the Oregon Station in the development of new products, such as prune pulp, partly dried prunes, and dried prune halves, the use of which should enlarge greatly the market for Oregon fruit.

Pectinol may be effectively used in the clarification of apple cider, according to the Michigan Station, if the pectinol-clarified and rough-

filtered juice is flash-heated to from 190° to 195° F. for from 7 to 20 seconds, run into sterilized bottles, and cooled promptly. With this procedure, sedimentation did not follow, and a desirable product was obtained.

At the New Jersey Station, undesirable residues of lead, arsenic, and sulphur were removed successfully from sour cherries by washing in a 1-percent solution of hydrochloric acid. The cleansed fruit kept as well as the unwashed and was better in appearance.

That the oil taken from the nuts of seedling tung trees varies greatly in quantity and quality was revealed by studies at the Georgia Station. In some instances the oil did not meet the specific requirements of paint and varnish manufacturers. The nuts from any given tree were fairly constant in qaulity from year to year, indicating possibilities in selecting desirable parental stocks.

VEGETABLES

Noteworthy progress was again shown in the field of vegetable production, particularly so in economy in the use of fertilizers and in the breeding of better-quality varieties.

Varietal improvement.—Of a great number of strains of Iceberg lettuce tested by the New York (Cornell) Station for adaptability to the State, a stock obtained from the Department of Agriculture (B.P.I.) breeding grounds in California was found outstanding in tipburn resistance and other desirable characters. The strain known as Imperial 44 was increased for distribution to New York State growers.

Comparisons by the Wisconsin Station of hybrid sweet corns with open-pollinated Golden Bantam and Country Gentleman were in favor of the hybrids, both in quantity and quality of the packed product. The hybrids differed among themselves in productivity, necessitating careful selective trials. The superiority of hybrids rested partly in their greater uniformity in ripening.

A new garden pepper, Windsor A, developed by the Connecticut (State) Station, was awarded a special certificate of merit when entered in the competition for all-American selections of the American Seed Trade Association.

Studies by the Connecticut (State) Station of the nature of the red pigments in garden beets yielded a simple method for measuring the quantity of pigment which is proving very helpful in the breeding program for the improvement of the beet. Pale and uneven color in beets is a decided detriment in the canning and market-garden industries.

Considerable progress was made by the experiment station of the University of Puerto Rico in the development of eggplants possessing resistance to bacterial wilt and cucumbers resistant to downy mildew. Seven resistant cucumbers had reached the stage of extensive field tests.

Crosses at the Iowa State College between the cultivated tomato and currant-fruited form showed in the first generation a dominance of the genetic characters of the wild parent. Chromosome behavior was normal in both types, and the hybrid behaved normally, for the most part, all of which is fortunate since the wild type is being used

by various plant breeders as a source of disease-resistant characters in tomato improvement.

Colorado Sweet Spanish No. 6, developed by the Colorado Station, proved a valuable addition to onion varieties. The new onion is late in maturity, of uniform spherical shape, deep-brown color, of good keeping quality, and very tolerant to thrips, a serious insect pest.

Marked success was obtained by the California Station in the development of new varieties of tomato resistant to the spotted wilt disease. From crosses of the resistant red currant form of tomato with cultivated varieties, there were secured certain seedlings combining resistance and the size and other good qualities of the large-fruited parents. Substantial progress was also recorded by the station in the production of onions possessing resistance to downy mildew and to pink root disease, both serious handicaps to the onion growers. A new downy mildew-resistant onion was nearly ready for distribution.

By inbreeding and selection, the Louisiana Station isolated a strain of okra practically free of spines and sufficiently promising to be distributed under the name Louisiana Velvet. From the Alabama Station was distributed a strain of the common garden bean known as Alabama No. 1 valuable for its resistance to root knot and drought. For 8 years the new strain has proved outstanding as a home-garden variety for southern gardens, where at certain periods of midsummer there is a great scarcity of vegetables.

Among interesting findings obtained by the Iowa Station in watermelon-breeding studies was that the difference between elongate and spherical fruits is determined by a single pair of factors or genes lacking dominance. A high correlation was noted between shape of the young ovary and that of the mature fruit. Dark-green rind was dominant to light-green, and was determined by one gene, although other genes apparently influenced minor variations in the light color.

Based on studies of growing material and on the literature, the New York State Station published a monograph, illustrated in color, on cucurbits, including squashes, pumpkins, muskmelons, and cucumbers which have been grown in the Northern States. A promising new early ripening tomato variety bred by the station was named "Redcap."

Cultural studies.—Results of studies by the West Virginia Station indicated that hardening of young tomato plants even to a moderate degree had a stunting effect on the plants, did not increase hardiness, and decreased early yields of fruit.

Based on two seasons' work by the Michigan Station, home-grown tomato plants are conceded superior to southern-grown plants in growth, survival, and freedom from diseases. The greater cost of producing home-grown plants was offset by the increased yields, but there still remained the practical difficulty of growing sufficient plants for the canning-crop producers.

Close spacing of Gulf State and Marglobe tomato plants, pruned to a single stem, was found by the Mississippi Station to increase both marketable and total yields.

In a discussion of the nutrient-solution method of growing greenhouse crops, the Indiana Station pointed out that the solution method is not new and is not basically different from soil culture. A subirri-

gation method of supplying nutrients was described, and formulas for nutrient solutions were presented, with caution as to their use.

Observations at the Winterhaven (Texas) Substation showed that under irrigation Yellow Bermuda onions yielded more profitably from transplants than from direct seeding. Spacing between rows of 14 inches usually gave higher yields than did greater distances. Too frequent irrigation often reduced yields, but proper timing of irrigation was a potent factor in increasing production.

In cooperation with the Department of Agriculture (B.A.E.) the Virginia Truck Station found that of seven fertilizer mixtures applied at the rate of 1,000 pounds per acre to garden peas, those applications mixed with the soil before planting, placed above the seed on the surface after planting, or placed in a band 3 inches below the seed resulted in decreased germination. Many of the seeds that germinated showed injury, and with all three placements the injury occurred on the taproot near the seed and not at the extremities of the secondary roots. The injurious effects were noticeable throughout the growth of the plant, and the severity and amount of injury was correlated with composition of the fertilizer. On the other hand, fertilizer placed in bands on each side of the row and below the seed level did not influence germination.

Further evidence was secured by the Virginia Truck Station that placement of fertilizer in narrow bands on each side of the seed row is the most effective method. Greenhouse studies showed that injury to seed by fertilizer varied inversely with the moisture content of the soil. Celery, set 6 by 12 inches in coldframes and fertilized with 2 tons per acre of a 6–6–5 fertilizer, responded to as much as 600 pounds of additional nitrogen per acre applied in fractional amounts in irrigation water.

Vegetable crops varied greatly in their tolerance to boron applied to the soil in the form of commercial borax. The moisture and organic-matter content of the soil were factors in resistance or susceptibility to boron injury.

Working in cooperation with the Department of Agriculture (B.A.Eng.), the New York (Cornell) Station found that better celery could be grown with half as much fertilizer if applied in bands on each side of the row just following transplanting.

In fertilizer experiments with asparagus at the Sandhill Substation, the South Carolina Station observed that the omission of potash caused an immediate and significant reduction in yield and grade of asparagus, whereas the omission of phosphorus did not lower yields significantly until the third year of the differential treatment.

At Willard, the North Carolina Station found that high percentages of potash did not increase significantly the yields of early cabbage, but there was an indication of somewhat earlier maturity. High percentages of phosphorus caused both early maturity and greater total yields. High nitrogen was necessary to the production of satisfactory yields.

Complete fertilizers were found also to be essential to the production of satisfactory cabbage yields by the South Carolina Station in experiments at the Charleston Truck Station.

A balanced nitrogen and phosphorus fertilizer was found effective by the Arizona Station in promoting the development of large,

solid lettuce heads. Ammonia salts alone increased size but reduced solidity and resultant shipping quality. Calcium nitrate proved a valuable side dressing and was most effective when applied in a series of light applications rather than in one large treatment.

Lime as a factor in the nutrition of the tomato was demonstrated by the New Jersey Station, where it was noted that lime increased yields as much as 3 to 4 tons per acre. Magnesium limestone was more effective than calcium limestone. In some cases lime created a potassium shortage because of the increased use of potassium by the larger plants.

Working with greenhouse tomatoes grown both as fall and spring crops, the Illinois Station found that excellent spring crops could be grown with rotted manure as the only fertilizer. In fact, in some cases supplemental nitrogen and potash were actually detrimental. In all cases the spring crops were much larger than the autumn—so much so that the station recommended the culture of the spring crop only.

The Pennsylvania Station was unable, with apparently excessive applications of nitrogenous fertilizers, to reach a point of overvegetativeness and diminishing yield in spring crops of greenhouse-grown tomatoes.

Physiological studies.—By measuring the resistance of celery petioles to a cross-cutting wire, the New York (Cornell) Station was able to establish definite differences between varieties in respect to stringiness. The collenchyma strands were the most resistant elements in the petioles, but because of their easy separation from the other tissues, the vascular bundles were much more conspicuous.

The optimum temperature for lycopene (red pigment) formation in the tomato fruit was found by the Minnesota Station to be 76° F. No lycopene was formed above 86°, and chlorophyll decomposition in tomato fruits was prevented by temperatures of 104° or above. In the watermelon, a rise in temperature from 68° to 98.6° did not check the development of red pigment, indicating a different mechanism for lycopene formation in the melon than in the tomato. In the presence of suitable temperatures, ethylene hastened chlorophyll decomposition and lycopene formation in the tomato. Light hastened chlorophyll decomposition, whereas lycopene formation proceeded equally as well in light or darkness.

Seeking an explanation of the wide difference in productivity of small- and large-seeded types of lima beans, the South Carolina Station found that the more productive small-type plants had greater chlorophyll, carbohydrate, and nitrogen contents. In addition, the breathing pores or stomata of the small types were open for a longer period each day, and the pollen germinated more promptly following opening of the blooms.

Studies by the Georgia Station of the structure of the flower of the garden pepper and of its behavior following pollination showed that both temperature and length of day are important factors in determining the time of opening and length of time elapsing between pollination and actual fertilization. At from 70° to 80° F., 42 hours passed between pollination and the first cytological evidence of fertilization. The higher the temperature, up to from 90° to 100° F., the more quickly did the flowers open.

ORNAMENTALS

Nutrition.—Studies by the New York (Cornell) Station of the effects of excess nutrient salts of various kinds on different greenhouse flowers showed certain specific detrimental responses. For example, with roses an excess of ammonium sulphate produced light-green leaves with dark-green veins. Nitrate of soda in excess defoliated roses. Potash in excess discolored the margins of the more mature leaves. Superphosphate in excess caused the stems to harden abnormally.

Briarcliff roses grown by the New Jersey Station in sand in glazed pots and supplied with zinc in differential amounts all showed root injury, the rapidity of onset and extent of which varied with the quantity of zinc. Even with 1 part per million, some blackening of roots occurred, leading to the question whether zinc in any amount has a place in rose nutrition.

Propagation.—The wave of interest in the use of chemicals for increasing and accelerating the rooting of ornamental plants was manifested in the many experiments reported. At the Alabama Station, of 4 chemicals tested on 23 ornamentals, indolebutyric acid gave consistently the best results, both in number of rooted cuttings and in root development. The chemicals had a more marked influence on normally difficult-rooting species than on those that root easily.

Striking increases in the percentage and quality of rooting of azalea and rhododendron cuttings were secured by the New York (Cornell) Station when half-ripe wood cuttings were treated with indolebutyric acid. On an average, the time required to root was reduced by 2 weeks.

The use of growth-promoting substances in stimulating rooting of cuttings of woody ornamentals was given a rather complete trial at the Ohio Station, where both crystalline acids and proprietary compounds were used for treating more than 100 species of cuttings. In general, the greater response was secured from young cuttings, possibly because of a greater content of natural growth-promoting substances. Of the total number, 57 species rooted and showed some response to treatment. No significant difference was noted between the crystalline acids and the proprietary materials.

Cuttings of a total of 45 species of azaleas, rhododendrons, laurel, and related plants were treated at the New York (Cornell) Station with growth-promoting substances. Indolebutyric acid caused 31 of the species to show a higher percentage of rooting as compared with the control lots. With 12 species there was no apparent difference, and in 2 cases the control lots were the better. Indoleacetic acid, as a whole, was not so effective as indolebutyric in root stimulation.

Light studies.—Further evidence was secured by several of the stations on the possibility of regulating the time of bloom of various ornamentals by modifying the length of day under which the plants were grown. That such control has economic possibilities for the commercial florist and much interest for the home gardener goes without saying. At the Alabama Station, asters given from 4 to 6 weeks of supplementary illumination in their early life were greatly

accelerated in coming into flower. Early-, midseason-, and late-flowering varieties bloomed on an average 33, 46, and 74 days earlier than the corresponding normal-day plants. Timed properly, there was no material reduction in quantity or quality of the flowers.

Because of the nature of the species, opposite results were secured with the chrysanthemum by the Mississippi Station. Pompon varieties grown under 3 hours of supplementary light for periods of from 4 to 8 weeks were retarded from 2 to 6 weeks in time of flower-bud formation. That intensity of light within reasonable limits is not a factor was indicated in the fact that 50-, 100-, and 150-watt lamps were equally effective when operated under similar conditions.

FORESTRY

The aspects of forest research that relate directly to the farm are being given increasing attention by the experiment stations. The part that the farm wood lot plays in the welfare of farm people is apparent, in supplying firewood for the home and for sale, and in furnishing lumber for repairs and posts for the farm fences. In the treeless areas, windbreaks bring great comfort to people and animals and make possible the growing of gardens and fruit trees to furnish a variety of foods.

Species trials.—The discovery of cones containing viable seed on 6- and 11-year-old slash pine trees planted out of their natural zone led the Alabama Station to suggest that this pine may prove of great value for reforesting approximately 12,000,000 to 15,000,000 acres in Alabama, where the species does not now grow.

Tree tamarisk, introduced into Arizona from Algeria in 1911, was found by the Arizona Station to be well suited for windbreaks and shade and to be an excellent source of fence-post material when treated with creosote. The long vertical vessels were helpful in carrying the creosote upward through the posts.

Physiological studies.—A significant relationship between acid-base balance and rate of decomposition of forest leaves was noted by the West Virginia Station. Black walnut, black locust, and maple leaves, found high in base content, decomposed rapidly, in contrast with such species as the pines, birch, and sycamore of low base content.

Of various factors involved in the loss of water from forest lands, transpiration is conceded by the California Station to be the most difficult to evaluate. Available records suggested that annual transpiration for forests ranges between 5 and 15 inches and may reach 35 inches in dense stands on best-quality sites. Run-off may approach 100 percent on areas where the vegetation has been heavily grazed, cut, or burned.

Silvicultural studies.—The value of releasing white pine from competing jack pine was shown in an accelerated height growth following thinning operations conducted by the Minnesota Station. In the 10 years following full release, the white pines averaged 50 percent greater height increment per year than did the comparable unreleased trees.

Thinning of 27-year-old jack pine stands to 768 and 1,105 trees per acre, as compared with 3,040 on the unthinned plats, resulted in a

significantly increased volume at the end of 10 years. More precipitation reached the soil in the thinned plats, yet soil moisture was apparently affected but little in the various layers. In the heavily thinned stand, the evaporation rate was higher, significantly so at the soil surface. Soil temperature was notably higher in the thinned plats at all depths, and a temperature that would permit root development was reached 10 days earlier than in the unthinned areas. On the whole, the most significant ecological effect of thinning was on soil temperatures.

Light cuttings in oak stands at frequent intervals were observed by the Arkansas Station to reduce the annual loss from decay, due apparently to the removal of inferior trees and to promoting conditions that favor production from second growth. Taper or bark width curves, based on measurements of trees of smaller diameters could not be reliably extended on their trends to include larger diameters.

In studying ways and means of reducing breakage losses during logging operations with redwood, the California Station found that losses could be reduced materially by the preparation of good layouts, felling in more than one round, and preventing the crossing of timber. With care it was possible to reduce breakage losses to below 5 percent, as compared with the frequent 20-percent loss with careless handling.

Observing the development of bluegrass in rings beneath locust saplings the Pennsylvania Station sampled the soil in the zone from 2 to 5 inches beneath the trees and some feet distant and found that the pH value of the soil beneath the locust trunks had risen from about 5 to near neutrality. The amounts of active calcium, magnesium, and potassium were significantly higher near the trees, suggesting that the decomposing locust leaves had enriched the soil. In four of five pairs, nitrates were higher near the trees.

Based on field observations, physical analyses, and pH-value determinations of soils on over 200 plats in four counties, the Arkansas Station found that the greater the slope, the slower the height growth rate of shortleaf and loblolly pines. Loblolly was usually absent on sites of greater than 7-percent slope, and where the slope was less than 1 percent, growth was poor due to inadequate surface drainage. Shortleaf pine was particularly susceptible to poor surface drainage. The best soils included none that were decidedly lacking in nitrogen or phosphorus, and the poorest soils included none that were high in these nutrients. In the situations under study, the direction of the slope has a negligible effect on the growth rate.

Stating that the New England area, as a result of glaciation, is composed of soils of a diverse character, the Connecticut (State) Station distinguished three major forest regions: (1) Oak of Connecticut and Rhode Island; (2) white pine of Massachusetts, the Connecticut River Valley and Lake Champlain sections of Vermont, southern New Hampshire, and southwestern Maine; and (3) the spruce and northern hardwood region of northern Vermont, New Hampshire, and Maine. The growth and relatively poor quality of much of the existing timber is conceded on the whole to be more a question of silviculture than of unfavorable soils. As a beginning to a study of red pine, the Connecticut (State) Station published an alinement chart and a volume table based on data taken in thinning 22 permanent plats in plantations.

AGRICULTURAL SOIL SCIENCE

CONTENTS

There is probably no property of a soil, known or yet to be brought to light, nor any activity or change occurring in it, that does not in some way influence directly the plant life it supports and feeds, and thereby, indirectly, the whole structure of our agricultural industry. The increasing demand of economic conditions for a more efficient agriculture is, therefore, in its most fundamental aspect, a demand upon our agricultural research institutions for intensified effort toward a broader and more thorough understanding and control of every property and activity of our soils. This demand is being most creditably met by the experiment stations. The statements that follow are to be regarded only as scattered examples of the result of a growingly coordinated and effective attack upon the most fundamental of agricultural problems.

SOIL REACTION AND ITS CONTROL

An overliming injury caused only by heavy liming of very acid soils has been observed by the Vermont Station, and the general nature of the toxic substance formed has been determined. This injury did not at first appear to be due to nutritional deficiencies; it often killed seedlings before they could exhaust even the food reserves of the seed itself. Podsolized soils (soils having most of their bases leached out of the top layer) became especially toxic. Normal soils of high organic-matter content gave a like result when their bases were removed with acids before liming. The poison was hard to destroy, but could be removed by removing all the organic matter. Tannin-bearing vegetable material, especially the barks of the evergreens normally found on podsolized soils, produced like poisons when made acid and then limed. The overliming poisons appeared to be phenolic resins related to certain tannins. Synthetic resins of this nature were made and found to produce typical overliming injury. Various means of blocking the activity of certain chemical structures in the organic compounds in the soils containing the overliming poison were tried in an effort to identify the structural unit causing the poisonous effect. Only decarboxylation—that is, destruction of the acidic part of the organic acids present—destroyed the toxicity.

In still more recent work the Vermont Station has found, in spite of the unquestionable formation of an organic poison in overliming, that small applications of boron compounds (15 to 25 pounds per acre of boric acid, for example), overcome the injury. The calcium silicate and the Canadian wood ashes which had previously had a curative effect were shown, by a very sensitive test, to contain traces of boron compounds.

An overliming injury, different in that no toxic compound has thus far been discovered, has been found at the Alabama Station on a Norfolk loamy sand, on which practical crop failure sometimes followed liming. Basic slag, even enough to make the soil alkaline, did not cause such failure. Boron compounds, in the proportion of 1 part per million of the element, prevented this form of overliming injury. The possible absorption of boron compounds by microorganisms after the liming is suggested.

Means for acidifying the subsoil to control plant diseases were sought at the Texas Station, where various quantities of sulphur and of sulphuric acid were added to the upper 5 inches of a Lufkin fine sandy loam. The greatest acidity in the surface soil appeared within 10 weeks, that of the next 2 or 3 inches within 4 months. The results were followed for 5 years. Penetration of acidity to more than 2 or 3 inches below the layer actually treated could not be obtained without making the surface soil too acid for plant growth. Increase in exchange-complex acidity (exchangeable hydrogen) after 5 years was equivalent to about 60 percent of the added acid. Single applications of acid to the surface soil were shown not to be a practical method for acidifying the subsoil for control of soil-borne plant diseases.

Alkali soils have been found, at the Arizona Station, seldom to contain alkali sufficient, in itself, to be poisonous to plants. The plants die of starvation in such soils because, in the absence of carbonic acid, they cannot absorb nitrate or phosphate.

MINERAL NUTRIENTS, FIXATION, AND BASE EXCHANGE

An increased interest in magnesium as a possible part of the nutrient requirement of some soils has followed the observation of an insufficiency of this element in Maine potato soils, in some tobacco soils where added magnesium is needed to prevent sand drown, and at other points. The Rhode Island Station found magnesium sulphate readily utilized by potatoes. Magnesic limestones gave more variable results, and the minerals serpentine and olivine had a magnesium value to this crop about that of the poorer magnesic limestones. Nitrogen fixation by the root-nodule bacteria of soybeans at the Missouri Station was greater at the higher levels of magnesium content in clay in which the calcium level was constant. Nitrogen fixation failed at low calcium content in absence of magnesium, but not when a small supply of magnesium was also present.

Nonacid-forming fertilizers have also been given increasing attention recently. The Connecticut (State) Station points out that the acid-forming nitrogen sources (ammonium salts, urea, etc.) often overbalance the components which leave a basic residue in the soil. Continued use of such a fertilizer may develop an injurious soil acidity. A fairly liberal liming practice will overcome the acidifying tendency, but a soil already of a desirable reaction is best kept so by nonacid-forming fertilizers. The Indiana Station has shown calcium silicate, fine dolomite, calcium carbonate, and tricalcium phosphate to rank in this order of decreasing value for rendering fertilizers nonacid-forming. When any of these neutralizers was added to the fertilizer, nitrification was better than when the fertilizer alone was

used. At the West Virginia Station, soils given fertilizer without basic supplement became very acid. This station also reports that the calcining of rock phosphate, which renders most of the phosphate soluble in citrates (availability test), also makes about two-thirds of the calcium available for neutralizing acidity. At the Virginia Truck Station the fineness of the limestone used in dry-mix nonacid-forming fertilizers was found important. Dolomitic limestone had to be at least of 100-mesh fineness to be effective. Such limestone also varied in effectiveness with its source.

Phosphate fixation prevents the usual fertilizer phosphate from penetrating the deeper root zone. The Nevada Station has shown that organically combined phosphate escapes such fixation and reaches all parts of the root zones. The station has made progress in the cheap quantity production by fermentation of glucose in the presence of phosphates of such penetrating phosphatic compounds. The New Jersey Station has shown that phosphates are converted into organic form in the cells of micro-organisms during decomposition of plant residues in soils and are again liberated (apparently with a breakdown of the microbial cells) in a later stage of the decomposition.

Potassium fixation has been shown by the New Jersey Station to be associated rather with the soil phosphates than with silicates. Iron, aluminium, calcium, and magnesium silicates fixed no potassium under the conditions of alternate wetting and drying to which natural soils are subject. The phosphates of the same elements, subjected to the same conditions, did bring potassium into insoluble combinations. The problem of the release of potassium fixed in the soil is therefore intimately tied up with that of the mobilization of phosphates. Various minerals studied at the Wisconsin Station showed some potassium-fixing power, but did not compare in this respect with clays. Extracting the free alumina from the clays reduced their fixing capacity, and replacing the alumina restored the fixing power. The fixation in soils and in decomposed granite which had been extracted with acid was lessened as the colloidal alumina was lessened. Fixing power was increased again when either alumina alone or alumina with silica was added, but not when silica alone was restored. At the Delaware Station a silt loam, a loam, and a sand were all found to fix potassium. Liming increased the fixation. A calcareous black clay loam showed extensive fixation of potassium at the Tennessee Station, whereas an acid red clay subsoil permitted extraction of practically all added potassium under like conditions.

Granulated fertilizers as a means for protecting readily soluble phosphates and potassium from fixation in nonavailable form have been studied by the New York State Station. By allowing granulated fertilizer 14 weeks' direct contact with Ontario loam, which has a high phosphate-fixing power, this station was able to show that approximately 9.5 out of an original approximate 10.5 percent of soluble phosphate remained in the fertilizer granules and had not been rendered nonavailable. The alternative procedure, laying concentrated bands of nongranulated fertilizer close to the plants, may be objectionable, though it does protect against fixation. At the Nevada Station dividing root systems among three pot compartments supplying phosphate, nitrogen, and potassium separately caused severe unilateral injury to the plant and led to the conclusion that

when a soil "is deficient in a given nutrient, and that nutrient is supplied to a fraction of the root system only, the same adverse factors [unilateral supply of the deficient nutrient] may be operative, although to a lesser extent."

The availability of phosphates calcined at 1,400° C. with silica enough to cause volatilization of much of the fluorine of the phosphate rock has been shown at the Pennsylvania Station to be equal to that of superphosphate. At the Iowa Station the availability of soil phosphates was increased by carbon dioxide, either the gas or its water solution, regardless of whether the carbon dioxide lowered (as would be expected) the pH value of soil or raised it, as actually occurred when rock phosphate and calcium carbonate were present in the treated soil. At the Indiana Station the Neubauer method (chemical determination of the phosphate and potassium taken up by seedlings from the soil to be tested) has been found accurate enough for use as a standard for checking directly chemical availability tests of phosphate and potassium.

Rapid chemical tests for soil-nutrient requirements have commanded widespread attention. The Connecticut (State) Station compared various phosphate tests as applied after phosphate fertilizer had been for some time in contact with the soil, checking the results by two pot-grown tobacco crops. Certain methods using extracting solutions of pH 3 or lower (rather strongly acid) extracted rock phosphate which was quite unavailable to the plants. The method long in use at this station agreed better with crop results, but was thought perhaps to show slightly less than the true availability. In a conservation program, the New Hampshire Station, having examined the results from a large number of soils, finds it possible to base lime- and fertilizer-treatment recommendations on rapid chemical soil tests with very generally satisfactory results. Using a replacement method (not a rapid test), the Oklahoma Station found soils yielding less than 60 parts of potassium per million showed a good response to potassium fertilizers; 60 to 100 parts, some response; 100 to 200 parts, doubtful to usually no response; and over 200 parts, no field response. Comparison with quick tests found the latter generally in agreement. The Connecticut (State) Station's system of rapid tests has given good results at the New Jersey Station. The practical interpretation of rapid chemical soil tests has been studied at the Michigan Station. At the Indiana Station the presence of raw rock phosphate in the tested soil led to overhigh results for phosphate availability. The test also tended to high results on sandy soils and subsoils. It applied well to about three-fourths of the State soils. The rapid potassium test indicated exchangeable soil potassium very well. At the Colorado Station a mold fungus, *Cunninghamella* species, was used in a test of soil-phosphate availability. Only phosphate differences had any appreciable effect on the rate of growth of this mold, which seemed to be of value for phosphate tests on calcareous soils.

Exchangeable bases in soils were found by the New York (Cornell) Station to be affected by forest cover. White and red cedars and white ash tended to maintain a high exchangeable base supply in the upper layer (A horizon). Hemlock raised the acidity and low-

ered the exchangeable base supply in the surface soil. The New Jersey Station reports and explains an effect of organic matter and phosphorus upon the exchange complex by which the exchange capacity of the soil is increased. The Iowa Station also noted an increased exchange capacity due to adding organic matter and found this improvement to be greater when leguminous material was added than when nonleguminous residues were incorporated. The Maryland Station determined the loss of exchange capacity resulting from the removal of organic matter from a wide range of soils and showed that light-textured soils cannot retain large supplies of exchangeable potassium. Their subsoils were of even less retention capacity. Unless the exchange capacity of these soils is increased by incorporating organic matter, potash fertilizer should not be applied in large amounts, but more often.

The trace-element requirements appear mainly in the form of deficiency diseases, taken up in the next section. At the Delaware Station, though a deficiency disease of crops seems not to have occurred, 50 pounds of copper sulphate to the ton increased the value of truck crops by from 4.47 percent (sweetpotatoes) to 43.55 percent (lima beans). The average tobacco value was increased 38.85 percent, of which 18.4 percent was yield increase and 15.45 percent quality improvement. The growth curve of mustard plants given various minute quantities of copper at the Florida Station appeared similar to that obtained with varying supplies of the more common nutrients.

MINERAL DEFICIENCIES AND TOXICANTS

At the Maine Station a lack of sufficient magnesium, already known as a deficient nutrient in some potato soils, has now been indicated as the probable cause of apple leaf scorch. In an orchard in which all the leaves of some untreated trees were affected, trees treated with magnesium sulphate showed very little scorch.

Iron deficiency was shown at the Massachusetts Station to be the apparent cause of a chlorosis of cultivated blueberries.

Boron, long known as poisonous to plants in more than very minute percentages in the soil, has in recent years gained a widening recognition as essential, in traces, to prevent specific boron-deficiency diseases. At the New York (Cornell) Station the serious internal cork, rosette, and incipient dieback disease in Champlain Valley apple trees was promptly cured by boric acid injected into the trees or borax applied to the soil. Injury from direct application in the tree was avoided by placing a suitable dose of borax about the affected tree in early spring. Like treatment cured this condition (formerly called drought spot in the Pacific Northwest) at the Washington Station. It was of no value for cork spot of Anjou pears or black end trouble of Bartlett, however. The Michigan Station has established characteristic boron-deficiency symptoms for sugar beets, red clover, alsike clover, and sweetclover. Increased yields of alfalfa and alsike clover resulted from small applications of borax. Many Michigan soils appeared probably to need some boron for sugar-beet and leguminous crops. The Wisconsin Station found lettuce unable to grow normally or to produce a second growth of leaves when cultivated in quartz-sand cultures without boron. The exceedingly minute quantity of

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boron needed is well shown in this station's observation that a hard borosilicate glass, very resistant to chemicals, acted as a good source of boron. Milorganite (activated sewage sludge containing traces of boron) made possible a nearly normal growth and an increased boron content in lettuce. A cracking of celery stems, such as to render the crop unmarketable, was shown by the New Jersey Station to be due to boron deficiency. The application of 10 pounds of borax to the acre with the fertilizer prevented these losses.

Zinc compounds, in very small quantities, have for several years been known as a cure for citrus mottle-leaf, though their action was of unknown nature. Zinc, with other trace elements, was needed for potatoes on peat soil at the Michigan Station. Experiments of the California Station indicate a minute quantity of zinc as one of the elements essential for healthy growth. A spray of zinc sulphate solution at the beginning of bloom prevented mottle-leaf symptoms in the following crop. The Puerto Rico Federal Station has found mottle-leaf to occur alike on acid, neutral, and alkaline soils. Use of a spray containing zinc was followed by marked improvement within 3 weeks.

Manganese deficiency detected after liming at the Rhode Island Station and subsequently recognized at many other stations, was found by the Michigan Station in peat soil pot cultures, in which the addition of this element increased onion and sweetclover growth. Citrus-leaf symptoms of manganese deficiency have been determined at the Florida Station and so defined as to be a reliable index of the need for supplying this requirement. Manganese appeared as a toxicant at the Louisiana Station, where excessive solution of the soil manganese was due to acidity. Liming cured the poisoning, which had caused a dwarfing and abnormal growth of cotton. The Florida Station cured a frenching of tung-tree foliage and chlorosis of several ornamental woody plants by either sprays or soil applications of manganese salts.

Copper was one of the trace elements needed on peat soils for potatoes at the Michigan Station.

Salinity and alkalinity (reaching a soluble-salt content up to 6,000 parts per million) were associated with apple measles by the New Mexico Station, where this disease appeared in one season in trees planted in soil containing from 1,000 to 4,000 parts per million of sodium chloride. Salinity and alkalinity are indicated as the principal factors in citrus decline in a 5-year field-plat study at the Texas Station. In soil free from excessive salt content the disease did not appear. Malnutrition seemed to have been induced by the saline-alkaline soil condition. Acid-forming substances, liberal applications of organic matter, and possibly certain of the trace elements appeared to be the means for bringing these trees again into profitable production. Adequate subsoil drainage was shown also to be important.

Soil accumulation of spray residues was found at the Oregon Station to be harmless to orchard trees because such compounds do not penetrate the soil mass deeper than the 6- to 8-inch layer into which cultivation tools carry them. That failure of orchard cover crops may sometimes be due to toxic soil accumulations of lead, copper, or arsenic compounds is considered quite possible, however.

ORGANIC MATTER AND NITROGEN

In forest soils the Connecticut (State) Station has shown that where the favorable condition of rapid decomposition of litter and its intimate mixing with the mineral soil exists, removal of the litter quickly injured soil structure. This is important not only for forest growth but also for erosion and flood control. Removal of litter lessened the percentage of soil-particle aggregates in the first inch of surface soil by about 40 percent, and in the next 2 inches by from 11 to 24 percent in 3½ years. Loss of aggregates in the surface inch reached 58 percent in 2½ years under some conditions. In orchard soils, the New Hampshire Station found clean cultivation to cause losses of from ½ to 1 ton of organic matter (calculated as dry substance) from each acre each year, a quantity difficult to replace by means of cover crops. The loss was due to rapid nitrification of the organic nitrogen and loss of its carbon as carbon dioxide. A sod cover, on the other hand, when it was supplied nitrogen enough to prevent competition with the trees for this element, maintained the organic-matter content. Competition for water was found unlikely to be a valid objection to sod culture. A soil with an adequate content of organic matter was better able to supply both trees and cover crops with water than one with low organic matter to supply the trees alone. In nursery soils, the fertilizer value of various organic residues or duffs formed under forest stand of various compositions was found by the Wisconsin Station to vary with the types of soil upon which it was developed. In a silt loam soil studied at the Washington Station decomposition of organic residues under the natural climatic conditions there prevailing resulted in the formation of a humus having a carbon: nitrogen ratio of approximately 12. Any carbon in excess of this ratio in the organic residues was rapidly lost as carbon dioxide.

Loss of nitrogen from stable manures by evaporation of ammonia was largely prevented, at the Vermont Station, by adding superphosphate. A 20-percent granulated superphosphate of high gypsum content was superior to the other phosphates used. Both the calcium sulphate and the monocalcium phosphate were found to take important parts in the reaction with ammonia. Nonvolatile ammonium sulphate was formed in a reaction the nature of which was elucidated. It was shown that the superphosphate should be added before fermentation takes place. Losses of nitrogen and organic matter due to cultivation and wind erosion in southern High Plains soils were determined at the Oklahoma Station. Drifted soils had an average content of 24.5 percent less organic matter and 28 percent less nitrogen than had uncropped soil. After being moved a large number of times, dunes of soils dispersed by wind finally became sands, regardless of the original texture.

SOIL MICROBIOLOGY

Effects of fertilizer components and organic residues on soil organisms have been studied at a number of the stations. The important soil-borne nitrogen-fixing genus, *Azotobacter*, has been found, at the Kansas Station, to be unfavorably affected by a high soil nitrate content. Numbers of these bacteria were reduced, temporarily, and it was also found that when the organism was grown for some time

in the presence of rather high nitrate concentrations some strains became unable to grow normally without combined nitrogen and could no longer fix atmospheric nitrogen. Some indication that other nitrogen sources have a similar effect was also obtained. At the New Jersey Station heavy applications of calcium cyanamide temporarily decreased the numbers of bacteria and actinomycetes in soil. The numbers of these organisms then increased very rapidly for about 30 days, after which they dropped to normal. At the same station, the rate of decomposition of green-manuring material was shown to depend on the proportion of water-soluble components, especially carbohydrates and nitrogen compounds. The moisture content most favorable to thorough decomposition was about 18 percent. The process was retarded at less than 9 or more than 27 percent moisture. Nitrate formation was depressed by more than 18 percent moisture. Numbers of bacteria, actinomycetes, and fungi were greatly increased by all the plant residues, but not to the same degree. At the Iowa Station *Azotobacter* was shown to be dependent upon a minimum value of about pH 6 and a phosphate content of about 50 pounds to the acre. Satisfaction of these requirements alone did not assure growth of this organism, however. Living higher plants were shown at the New Jersey Station, by a recently developed technique of microscopic observation, to favor a vigorous growth of soil organisms close about their roots and in actual contact with them. Effects of rotations upon the soil population have been studied at the Iowa Station. Legumes in the rotation favored a more stable population of two *Rhizobium* species. Ammonia-oxidizing organisms and legume bacteria also benefited by fertilizer treatments.

Bacterial colonies of visible size were developed on soil plaques at the New York (Cornell) Station by adding magnesium ammonium phosphate when no other mineral nutrient in use for such work brought about the required growth. By this means the station was able to show the presence of a bacterial flora in successive soil layers down to unweathered parent material. This station has also found means for obtaining pure cultures of soil algae, which will facilitate study of the practical significance of this part of the soil population.

Nitrification, recently asserted by some observers to be partly a light-induced (photochemical) reaction, has been found at the New Jersey Station to depend apparently on nitrifying micro-organisms alone. "The biological oxidation of ammonia to nitrite and of nitrite to nitrate must still be considered as the all-important process in the formation of nitrate in soil."

SOIL MOISTURE AND WATER MOVEMENT

The New York (Cornell) Station, cooperating with the Department of Agriculture (S.C.S.), finds field measurement of capillary tension to indicate available moisture in some ways more correctly than do moisture determinations. Similar measurements by the Iowa Station, also in cooperation with the Department of Agriculture (S.C.S.), indicated that the soil moisture was in the form of a connected liquid phase up to within a few inches of the surface. Adding organic matter to the surface 7 inches of the Marshall silt loam here studied lessened the capillary tension (that is, it lessened the te-

nacity with which the soil moisture would be withheld from plant roots). The Colorado Station, testing a simplified method there devised, obtained capillary tension curves for varying moisture contents "with sufficient precision to show the characteristic textural differences between soil types, and [the method] may serve as a measure of moisture-storing capacity." At the Utah Station the Darcy law, a mathematical expression of the movement of water in a horizontal tube of homogeneous sand, has been so generalized that it can be applied to the more practical relations between irrigation and available moisture supply, and to the study of drainage, erosion, and flooding. A study of moisture made at the Oregon Station shows that water will not move by capillary action more than a few inches at a rate fast enough to make such a movement of any value to trees. Infiltration also may be both very slow and very different in different parts of the same orchard. A great deal can be learned as to moisture conditions by the use of a soil auger or shovel and simple examination of the soil. More can be done by systematic sampling and moisture determination.

The rate and extent of infiltration have been studied at the Iowa Station, where the infiltration capacity of a Clarion loam under a corn, oats, and clover rotation, though relatively high at the start, was increased materially by additions of manure. Recognizing infiltration capacity as a factor in erosion-control practice concerning which more information is needed, the Illinois Station has set up a special type of lysimeter for the measurement of both run-off and percolation rates of eight soils.

SOIL CONSERVATION AND LAND USE

The New York State Station has shown that in the Northern States moderate slopes can be cultivated safely if erosion control is properly maintained. This station details 11 important and practicable measures of erosion prevention and remedy as a basis upon which such land use should rest. These include the use of phosphates to encourage the development of bulky root systems, and leaving grass in the waterways of sloping lands. The Oklahoma Station has found that in some soils the increase in replaceable sodium in the surface 6 inches from an application of 300 pounds of sodium nitrate amounted to about one-fourth of the sodium added. Soils with a low ratio of exchangeable calcium to exchangeable sodium readily deflocculate, or break down into fine particles which are very slow in settling out of water suspensions, and so are very liable to puddling, and to sealing over and running together on the surface after rain. Such a condition inhibits penetration of water, causing run-off, and erosion is aggravated by the nonsettling tendency. Soils of the plats thus fertilized had higher calcium to sodium ratios than the Solonetz (saline-alkaline) soils of the station's erosion study, but those plats showing the higher replaceable sodium content showed also the poorer physical condition. Soils having a good physical condition are those with a high ratio of calcium to sodium in their base-exchange complex. The same station warns against terraces built from "alkali spot" or "slick spot" soils. These soils are not only themselves deflocculated and highly erosible, but are also capable

of reaction with normal soil over which they are washed and deposited. The sodium-charged complex yields sodium enough to deflocculate the normal soil so that it is in turn rendered erosible.

Puddling of soils has been given special attention at the Arizona Station. Soil structure may be seriously injured in this way by the vibration of heavy farm implements. The structure of a puddled soil could be rebuilt by a dry fallow, restoring productivity. A dust mulch applied to wet puddled soil also improved its structures, with accompanying improvement in plant growth and plant-food absorption. Seed does not germinate in puddled soil except at a crack or other surface where aeration is not cut off. Moisture availability is very low in puddled soil, and the decomposition of organic matter in such soil does not follow a normal course but produces toxic substances which may retain their poisonous effect upon plants even after structure has been rebuilt by dry fallow. Plant food, whether naturally present or added as fertilizer, was shown to be of low availability in a puddled soil. Normal nitrogen transformations were inhibited by puddling.

Soil adaptations to specific agricultural uses have been considered at many of the stations. Soil characteristics necessary for profitable fruit production have been pointed out by the New York (Cornell) Station, the first essential being that of conditions favorable to deep rooting, which is important to good moisture supply. It is also noted that turning under good crops of sod, clover, or the like, either when the trees are young or before setting them, will improve even the best orchard sites. The Oregon Station also finds cover crops the best and cheapest means of maintaining orchard soils. Soil-building crops must be used on hill-soil orchards if they are to remain productive. Under the conditions dealt with at this station, early plowing under, about the first half of April, before the soil is robbed of its moisture was found a prime essential. The Ohio Station has found soil reaction to be a most important factor in determining the class and use of land. It was also necessary to take into consideration base-exchange capacity, degree of base saturation, the nature of the bases present, organic-matter content, and available plant nutrients. The classification of land surfaces into associations of soil and relief features, such groupings to be designated "pedonomorphic," has been proposed at the Michigan Station. The natural land type is considered more inclusive of the natural factors influencing the use and value of land than is the soil type alone.

SOIL COLLOIDS

Upon the colloids, comprising the finer clay particles and much of the more thoroughly decomposed organic matter, depend almost all of the agriculturally essential qualities of a soil. Division of any substance into particles so minute that they are invisible at the highest power of the microscope enormously increases the total exposed surface. Reactions of a type associated with surfaces only, rather than uniform reactions of the particle as a whole, then dominate. The chemical behavior of the soil colloids is of this nature. Before we can control, with any assured completeness, such vitally practical matters as the locking up of added plant foods in unavailable form,

the structure and tilth of soils, erosibility, and moisture supply and conservation, we must obtain a much more complete control of the soil colloids. The seemingly remote and highly technical chemistry and physics of colloids thus becomes a matter of close and important concern in agricultural research. We can no longer remove our agriculture to uncropped soils when we have used up the natural productivity of those in use. On the contrary, we may require more from the soils we now have than they have yet been made at any time to yield.

Attacking the colloid problem at its roots, the New Jersey Station has been, for some years, studying the physical and chemical laws of soil colloidal behavior. The question of the particle size below which definitely colloidal behavior appears has been studied at the Missouri Station. A distinct break in the properties of clay as compared with particle size was found at a diameter of about 1 micron, 0.001 millimeter, or about 0.00004 inch. In itself this fact has no direct agricultural application. As a part of the groundwork of an understanding of the behavior of soil colloids it is essential and basic. Of immediate practical significance is the observation at the same station that organic colloids, when saturated with either calcium or hydrogen ions, were several times as effective in cementing sand particles into water-stable aggregates as were the inorganic colloids. Stable-aggregate formation appeared to take place only on dehydration. The California Station, using X-ray and various other methods, found all results agreed in indicating a crystalline structure in the minute soil-colloid particle. The kind of surface exposed depends on this crystalline structure (and so upon the kind of mineral) and affects such soil functions as base exchange, some very practical phases of which have already been noted in connection with the behavior of mineral nutrients in the soil. A system of chemical base-exchange equations designed to clarify soil reactions of this sort and to cover both presence of calcium carbonate (as in calcareous soils) and contact with air, as in natural soil in situ, has been elaborated at the Utah Station. New light on base-exchange reactions has been obtained in a study of the chemical nature and crystal structure of the clay minerals at the Missouri Station. The Pennsylvania Station has carried out a study of the mineralogical make-up of the very fine sand fraction of five Pennsylvania soils, developing for this purpose an improved method for separating the various minerals quantitatively from one another. According to observations recorded at the Virginia Truck Station the phosphate-fixing power of soils is to be found in the basoid constituent of the soil colloid.

RESEARCH METHODS

Progress in the accumulation of reliable practical knowledge in any field of scientific investigation is rigidly limited by the adequacy of its equipment of experimental methods. A procedure giving exact information when applied to isolated single instances may become hopelessly slow and cumbersome, or even inaccurate, where a large number of replications of the single observation are required to establish an average value or to indicate the limits of probable variation. An analytical method, quite adequate when it was only necessary

to know that a soil did not contain enough boron to render it toxic to plants, might no longer be nearly accurate enough after the discovery that very much smaller quantities of boron are essential to plant life made it needful to determine soil boron in fractions of parts per million. And with the opening of each new part of the general field of investigation, either a new armament of experimental methods or, at the least, the retesting and adapting of existing procedure becomes an inescapable first step. The experiment stations are carrying on an active and very necessary part in this basic phase of soil investigation.

The New York (Cornell) Station has detected considerable differences in moisture content among experimental pots maintained under supposedly uniform conditions, affecting the pot-test results in determinations of soil fertilizer requirement. A simple procedure for obviating such wide discrepancies in moisture supply was devised. The New York State Station has pointed out the desirability of a greenhouse efficiency test, indicating the benefit to the host plant of individual cultures, as an improvement over present methods of testing commercial legume inoculants.

Means for preserving undisturbed soil structure in sections thin enough for miscroscopic study of natural structure and pore space have been devised at the Oklahoma Station. Photomicrographs of noncapillary pore space at low powers have been made and progress in adapting the method for high magnifications is reported. The color composition of soils has been analyzed at the California Station in terms of percentages of black, white, yellow, and red. Very poor agreement in designation of soil color by nonanalytical shade names was demonstrated. In such an analysis as that mentioned, however, soil colors are distinct and definable. They can be measured and their composition reported in brief, specific terms.

Certain types of mechanical and mineralogical analysis of soils demand removal of free oxides of iron and aluminum, colloidal silica, and organic matter without alteration of the remaining components. The Wisconsin Station has developed a method whereby this is done more rapidly and with less acid reagents than heretofore. It became possible to show that clay particle size could more usefully be given the upper limit of 2 microns diameter rather than the 5 microns previously taken as the upper limit. A hydrometer method for rapid mechanical analysis of soils, originated at the Michigan Station, was adapted by the Ohio Station for determining percentages of aggregated particles in soils. At the California Station a specific-gravity balance method for density of soil suspensions has been found to do about the same work as the pipette method and in considerably less time.

For measuring the relation between crop response and response of soil micro-organisms to soil treatments and varied fertility levels, the Indiana Station studied the measurement of carbon dioxide production by the micro-organisms 24 hours after adding mannitol. There was indication, in the results, of a possible basis for determining nitrogen and phosphate requirements. Potassium requirements and deficiencies in manganese, copper, and zinc were shown not to be detected in this way. At the New Jersey Station it has been pointed out that artificial culture media, liquid or agar, differ physically from

soil and provide nutrients different in nature and concentration from those the soil bacteria encounter in situ. On the other hand, soils, when sterilized for use as media, are altered so that not all of the results give the information required. A medium free from most of these disadvantages, readily duplicated, simple in composition, and very useful in practice was made up from sand and bentonite in proportions similar to those of sand and clay in loam soils.

Sources of inaccuracy in the readings of soil thermographs have been reported from the Montana Station, with means for correcting these errors.

PLANT DISEASES AND INSECT PESTS

CONTENTS

"The average person has very little knowledge of the important part that insect pests and diseases play in the cost of crop production," states a recent editorial in a leading fruit growers' journal. The farmer, however, suffers heavy increases in production costs and destruction of profits resulting from the widespread inroads of these enemies of his crops. He may have the best soil, the finest growing conditions, the most favorable rainfall distribution or supplementary irrigation and he may plant the highest-yielding varieties and give them ideal culture but all this may not result in profitable production. An apparently innumerable host of plant diseases and insect pests must be dealt with. There is no escape from them under the conditions of modern commercial agriculture which involves large-scale, concentrated production of the different crops in areas best adapted to them and creates situations more favorable to the multiplication of the pests and diseases of each particular crop than ever existed under more natural conditions. At the same time the various checks and balances that tend to limit these plagues in nature are upset, restricted, or destroyed in the artificial agricultural environment. Each pest and disease must be fought by the use of materials, machinery, and methods worked out by scientific research. Experience alone has given the farmer very few effective means of defense against the inroads of diseases and parasites. Science has provided the only really effective avenues of approach to the practical solution of problems of this type.

Many scientists in the State agricultural experiment stations and the Department of Agriculture are devoting their entire time to the study of crop pests and parasites, the development of economical and efficient methods for their control, and the breeding of varieties of

plants resistant to their attack. It is clearly recognized that work of this type must continue if agriculture is to maintain a position of relative permanence and economic stability. The following selected examples of recent work conducted throughout the country along these lines present an incomplete but suggestive picture of the extent and diversity of such investigations now under way at the State stations. In numerous instances the Department of Agriculture and the experiment stations are cooperating in these studies and many items listed are but individual units in larger coordinated undertakings of Nation-wide scope participated in by the Department and stations.

NEW AND RECENTLY INTRODUCED PESTS AND DISEASES

Although old pests and diseases are burden enough on agriculture, new ones are constantly making their appearance, some of them introduced from foreign lands and others perhaps developed at home from relatively harmless forms. With as great promptness and thoroughness as available resources permit, these newly found crop enemies are subjected to study in order to determine how best to deal with them.

Among the new or recently introduced diseases and insects of possible importance to agriculture being worked on during the year may be mentioned a new virus disease of apricot and a cutworm attacking gooseberries in Colorado; a cherry virus, known as mottleleaf, causing considerable injury in Idaho; the asteroid (star-shaped) spot of peach, also due to a virus, found in California; "purple top" of potato in North Dakota and Minnesota and perhaps identical with the "blue stem" trouble reported by the West Virginia Station; the so-called red stele disease of strawberry, possibly introduced from Europe, and now spreading rapidly in the United States; a chinch bug new to science found overwintering on one of the important pasture grasses of Iowa; the black wheat-stem sawfly which in 1937, two seasons after its first discovery, had spread to 11 counties in Ohio in addition to the 19 where it was found in 1936, and the advancing chlorotic streak of sugarcane, first found in Louisiana in 1937, and believed to be of virus origin.

FUNGICIDES AND INSECTICIDES

Chemical fumigants, dusts, and sprays are the only practicable means of protection against many crop enemies, but perfect protection at small expense accompanied by safety for the plant and absence of hazard for animals or man has rarely been attained. Hence there are few agricultural experiment stations which do not carry on a continuing program of laboratory and field research looking to the development of cheaper, safer, and more efficient materials. Rapid advance is being made. New preparations are appearing from commercial as well as from State and Federal laboratories. These are being tested out to determine their usefulness in different regions and for many different crops. Frequent reference to such work is made in the following sections in connection with particular diseases and pests. Additional instances may be mentioned here.

The Pennsylvania Station announced that, in the difficult task of sterilizing soil against soil-borne pests and diseases in seedbeds, in-

creased efficiency, economy, and timesaving were possible through use of an apparatus constructed to mix formaldehyde with steam vapor. In testing a long series of laboratory combinations of copper, arsenic, and lime, in the effort to work out practical eradicants for plant-disease fungi, the Wisconsin Station found much promise in the discovery that the total effectiveness of such mixtures is usually greater than the sum of the effects of the separate ingredients. The New York State Station, in a 5-year study of the effects of different chemicals on the germination of various kinds of seeds, found none to be satisfactory, with the possible exception of copper oxalate and dilute cuprous oxide, save the organic mercurial dusts or dips. Mustard oils and related volatile sulphur compounds have been investigated cooperatively by the Wisconsin Station and the Department of Agriculture (B.P.I.), to learn whether these plant-produced materials may possibly play a role in natural disease resistance or may have value in future plant-disease prevention. The discovery of high toxicity, particularly in the allyl oils, warrants continued exploration.

The tests being conducted by the Puerto Rico Federal Station on 238 surviving lots of plants, introduced for investigation as to their insecticidal properties, have given encouraging results. One plant, a *Lonchocarpus*, yielded the highest percentage on record (20.6 percent) of rotenone, a poison to insects and cold-blooded animals but comparatively harmless to warm-blooded animals or man. The successful growth of this plant would not only provide a new industry in the island, but would also supply the United States with an exceedingly valuable product that now must be imported largely from foreign territory. The Louisiana Station reports that certain spreading and wetting agents added to rotenone-bearing dusts increase their effectiveness.

At several stations studies of various nicotine products for insect control are being continued with the particular aim of replacing metallic poisons. The Louisiana Station has found common agar-agar effective for activating nicotine. The Illinois Station has demonstrated that a device completely vaporizing nicotine by the exhaust of an automobile truck is capable of producing a high and rapid kill of plant lice on peas in the field under a towed canvas hood. The discharge of nicotine vapor directly from a pressure can into the foliage of greenhouse plants was also found to give much better control of plant lice than the usual method of allowing the vapor to diffuse through the house.

The Tennessee Station has called attention to evidence considered as pointing to the probable absence of danger to health from certain fluorine-containing materials useful in insect control but at present employed only to a limited extent. The California Station is continuing its work on the control of certain kinds of insects by the use of electrocuting light traps. Additional cases are being discovered where this method can produce helpful results.

Progress in the study of materials, not of themselves toxic to pests, that help poisonous sprays or dusts to spread more evenly and to stick better on the plants has been reported by different stations, including Connecticut (State), New York (Cornell), California, New Hampshire, and New Jersey.

GRAIN DISEASES

With respect to stem rust of wheat the value of the service rendered by the experiment stations is strikingly illustrated in the relatively light losses sustained in 1938 from this disease in Minnesota and other parts of the United States where the Thatcher variety of wheat was grown, as compared with the estimated damage of 40–45 percent in the upper Red River Valley and other sections where susceptible varieties were grown. This superior rust-resistant wheat was developed cooperatively by the Minnesota Station and the Department of Agriculture (B.P.I.). Much of the State station work on cereal diseases is part of an effectively coordinated program of research carried on for many years in which this Bureau is aiding the States and the States are providing facilities for the Bureau. The entire country has benefited.

The practical value of breeding cereals for resistance to many diseases has been clearly demonstrated but the difficulty of the work is indicated by the fact that disease-producing fungi often occur in a variety of strains and resistance to one strain does not necessarily mean resistance to another strain of the same parasite. The Washington Station in cooperation with the Department of Agriculture (B.P.I.) has recently announced the finding of new physiological races of wheat bunt and, by crossing of bunt strains, has disclosed how virulent races of these parasites probably arise in nature. Other stations, notably those in Minnesota, Oregon, West Virginia, and Montana, have cooperated with the Department in determining the different biotypes of bunt and in testing the susceptibility of wheat varieties to them. Several excellent kinds of wheat have proved highly resistant to a large number of bunt races and give hope of success in combining resistance to all bunt races in a new series of high-quality wheats. The California Station has combined both smut and stem rust resistance in two important varieties, Baart and White Federation.

Seed-borne bunt may be effectively destroyed by chemical dusts. The Minnesota Station has recently developed a simple and inexpensive but efficient and rapid seed-grain treater the farmer can make himself. Infectious diseases of corn have been responsible for large losses to farmers in the Corn Belt as elsewhere. An illustrated circular for the guidance of corn growers in combating corn diseases, based on years of research, was published recently by the Illinois Station in cooperation with the Department of Agriculture (B.P.I.). This station has shown that seed treatment of corn is of even greater benefit for a number of leading corn hybrids than for open-pollinated varieties, and especially so in respect to soil-borne seedling blight. On the other hand, various seed-corn treatments were shown by the New Mexico Station to be ineffective under conditions prevailing in that State.

Bacterial wilt of corn, largely confined in the past to sweet corn in certain eastern sections of the country, has invaded the Corn Belt and become an important source of losses in field corn. Work is under way at a number of stations cooperating with the Department of Agriculture (B.P.I.) to develop resistant field corn types, to learn

further facts about the disease, and to develop other possible methods for its control. The Iowa Station has reported evidence suggesting that variant strains of the corn wilt bacteria are constantly being formed. By passing an ordinary type through a resistant kind of corn, the bacteria were made more virulent. These facts need to be taken into consideration in breeding for resistance. The corn wilt organism was also found able to attack various grasses, sorghum, and millet. The same station has contributed valuable information on how factors for wilt resistance are inherited. The possibility of using the bacteriophage principle against this disease is being studied by the Ohio Station, which reports an apparently strong connection between the resistance of a variety and the presence in its seed of transmissible substances capable of destroying the germs. This station has also announced that similar germ-destroying substances were found in extracts of rye, oats, foxtail, redtop, timothy, and winter wheat.

Deterioration of stored grain has become increasingly important in view of the growing interest in the holding of grain reserves and surpluses. The Illinois Station has tackled the problem of how low a moisture content shelled corn must have to prevent the growth of molds. The study of 17 kinds of molds brought out the facts that each kind may have a different minimum moisture requirement for growth and that commercial damage follows when the moisture content is 1 to 2 percent higher than this minimum. These facts will prove of the greatest value in handling future grain stocks.

Powdery mildew of barley is so serious in some sections of the country and so impractical to control by other methods that breeding for resistance is being resorted to. The California Station has found the variety Goldfoil to possess one major factor for resistance that breeders can use and the variety Hanna a different factor, neither of which is carried by three other resistant barleys being used as parent lines.

A new virulent strain of crown rust of oats (race 45) has arisen to which no domestic variety is completely resistant, according to an announcement by the Iowa Station where, in cooperation with the Department of Agriculture (B.P.I.), a long breeding program has produced the high-yielding Victoria Richland oat. This variety, to be released in 1940, is resistant to smuts, stem rust, and all other known strains of crown rust except the new one. Efforts are already being made to secure oat types resistant to race 45 to cross with the new variety in the hope of developing complete resistance.

Resistance to *Pythium* root rot in sorghum has been studied at the Kansas Station in cooperation with the Department of Agriculture (B.P.I.), and facts of use to the breeders of better sorghums have been evolved.

Cercospora spot of rice has been the object of a program of research by the Arkansas, Louisiana, and Texas Stations cooperating with the Department of Agriculture (B.P.I.), 58 varieties and selections having been found so resistant as to support the belief that control may be achieved along this line.

The common sheath spot of rice was traced by the Louisiana Station to its cause, a species of *Rhizoctonia* apparently new to science.

Rice seedling blight was found by the Arkansas Station to be due commonly to four different fungi, three of which are ordinarily seed-borne, but seed treatment materials gave little indication of consistent benefit.

GRAIN INSECTS

The southern cornstalk borer is said to be responsible for an annual loss of $2,000,000 in South Carolina. A 5 years' study by the South Carolina Station has shown that if planting is delayed until May, first-generation infestation will be very light.

Resistance to the southern corn rootworm has been found in certain strains of corn among those tested recently by the Illinois Station in cooperation with the Department of Agriculture (B.P.I.).

The wheat-stem maggot is widely distributed through the wheat-growing area of North America, and not uncommonly injures 10 to 15 percent and sometimes almost 100 percent of the plants. The Kansas Station, which has lately reported on several years' study of its life history and habits, found 18 different kinds of parasites assisting in the biological control of this pest in nature. Differences in infestation among wheat varieties indicated that breeding for resistance may be one of the best future lines of attack on this problem.

A sporadic wheat beetle (*Blapstinus*) was found by the Montana Station to be susceptible of control by poison bran mixtures.

The sorghum webworm is said to be one of the major pests of grain sorghums in Texas. The Texas Station found the use of insecticides impractical but showed that timely planting and clean-up after harvest were of advantage.

Grain-storage problems are seriously increased by pests that destroy large quantities of stored grain annually. Intensive effort has been devoted to finding more practical and economical methods of dealing with such pests. The Illinois Station has found that drying grain at high temperatures not only removes excess moisture but is capable of killing the insects present before storage. All grain weevils in corn were killed in 2 hours' exposure to 130° F., while the saw-toothed grain beetle in wheat required about twice as long and 10° more heat for a complete kill. The confused flour beetle, the granary weevil, and the rice weevil have been investigated by the Minnesota Station to determine their comparative sensitiveness to various chemical fumigants, including some new compounds of high toxicity. Methyl thiocyanate was found to be extremely effective. The Louisiana Station reports the development of weevilproof rice bags as a means of protection never used before.

COTTON DISEASES

The organization of the Cotton Disease Council in 1936 to include all workers on cotton-disease problems has facilitated joint investigations of considerable magnitude by the Department of Agriculture and the experiment stations in the Cotton Belt and is resulting in more rapid progress.

Phymatotrichum root rot is the most destructive cotton disease in the United States, causing average annual losses estimated at over $150,000,000. The Arizona Station has recently published a review of previous root rot investigations. Studies begun in 1925 have

shown rotation with nonsusceptible crops like cereals, together with clean culture, to be the most economical method of control for large areas in Arizona. Efforts to develop cotton varieties resistant to the fungus are reported as still in the experimental stage. The same is true for soil applications of sulphur which appeared promising in preliminary trials. The Texas Station published the results of detailed microscopic and culture studies on the way this fungus invades and works in the cotton roots, also the results of preliminary tests with various possible fungicides and fumigants showing their ability to penetrate the soil and to work at a distance from the point of application and their effect on living plants. Pentachloroethane, tetrachloroethane, and xylene were deemed worthy of further trial.

Seedling blight, sore shin, and damping-off, occurring widely throughout the Cotton Belt, are responsible for losses of millions of dollars annually. The South Carolina Station reports that the treatment of cottonseed with an organic mercurial dust has given such generally satisfactory control of these seedling diseases that in 1937 seed for a quarter of a million acres was treated in that State and resulted in increasing the value of the crop by an estimated $1,500,000. Similar reports come from other States. The Mississippi Station found that seed thus treated could be stored either in corncribs or buildings through two winters and then give a good stand when planted.

Cotton wilt causes substantial losses every year in many of the cotton States. Most of this wilt is due to a soil-borne fungus, a *Fusarium*, and extensive Federal-State cooperative investigation of this parasite is under way. Samples of the wilt fungus from widely separated regions, when tested at the Arkansas Station, showed a broad range in virulence. This station is also cooperatively testing different cotton varieties for evidence of relative wilt resistance, using a new timesaving and reliable laboratory method.

Verticillium wilt, caused by a different fungus, has appeared in Arizona at widely separated points under conditions strongly suggesting that it had been brought in with the seed. The Arizona Station also found this fungus in cultures from cottonseed. Acid-delinted seed, however, was not found to carry this form of wilt.

COTTON INSECTS

The boll weevil still occupies a leading position among the insect pests that plague the cotton States. The Oklahoma Station found it to be much more resistant to cold than had previously been supposed. The Texas Station, comparing a number of insecticidal combinations against this weevil, found none superior to calcium arsenate, although mixture with paris green or sulphur did not decrease its effectiveness. The Georgia Coastal Plain Station, cooperating with the Department of Agriculture (B.E.&P.Q.), found that while dusting for weevils was unnecessary with the quick-maturing upland varieties under the conditions of the experiment, it was not so with the sea-island cotton. With the latter, sweetened poison applied by mopping proved useful early in the season, but after the blooms were well established 5 to 6 pounds of calcium arsenate per acre gave good control, infestation being moderate.

The pink bollworm continues to receive attention. The Puerto Rico Federal Station, in cooperation with the Bureau of Entomology and Plant Quarantine, has worked with insect parasites of the pink bollworm. In cooperation with the Texas Station six of these have been introduced into Texas from foreign sources within 5 years, while in Puerto Rico more than 58,000 individuals of 3 imported and 1 native species have been liberated.

The cotton flea hopper appears likely to cause less damage where strip cropping with certain other plants is practiced, the Texas Station having shown that this insect prefers other crop plants or weeds to cotton and that injury to cotton is due largely to their scarcity.

Thrips, when numerous, are capable of doing considerable damage. Studies by the South Carolina Station have disclosed the occurrence of no less than 13 different kinds of thrips on cotton in that State. Various types of cotton-damaging bugs as well as thrips have been found by the California Station to be suppressed measurably by chemical dusting or in some cases by cultural practices.

TOBACCO DISEASES AND INSECTS

Tobacco diseases and insect attacks are believed to cause the growers in all sections more loss and uncertainty than any other factors affecting the production of this crop. More intensive and better coordinated attacks on tobacco-disease problems have been prosecuted since the plant pathologists of the Department of Agriculture and the experiment stations of the tobacco-growing States banded themselves together in 1935 in the Tobacco Disease Council. The Tobacco Insect Council, established in 1937, and functioning in much the same way, issued joint recommendations for tobacco-insect control for the various tobacco areas with the cooperation of the Department of Agriculture (B.E.&P.Q.).

Tobacco downy mildew (blue mold), a comparatively recent invader of this country, has now spread until it has become a major concern of planters from Florida to Connecticut. Because of it, an estimated $5,000,000 a year has been spent for increased seedbed plantings, besides the decreased income sustained. Work by the stations in the many tobacco-growing States in cooperation with the Department of Agriculture (B.P.I.) has demonstrated that while spraying with the relatively inexpensive red copper oxide and cottonseed-oil emulsion is usually rather effective in suppressing this disease, benzol or xylol vapor, particularly when applied by recently developed apparatus, is much less subject to uncertainties occasioned by unfavorable weather during the critical period. Another material which under preliminary trial appears promising is paradichlorobenzene, a well known crystalline insecticide.

Tobacco mosaic and other widespread virus diseases have continued to receive attention. The Kentucky Station reports more than 10 years' study as showing that mosaic has been successfully controlled in that State by requiring men who handle tobacco plants in the beds and fields to wash their hands and avoid all contact with the often contaminated barn-cured tobacco. Especially in the dark-fired area, where mosaic burn is very injurious to the most valuable top leaves, growers are increasingly putting these safeguards into practice with strikingly beneficial results. Heating cured tobacco one-half

hour in the oven at about 300° F. destroyed the virus without spoiling the tobacco. The Wisconsin Station, with the Department of Agriculture (B.P.I.), has found that among some 45 kinds of microorganisms tested, certain bacterial species are able to destroy the virus rapidly in juice from diseased plants. Such knowledge may lead to better elimination of the virus from fields where old infected plant remains and trash appear to constitute an important source from which the disease may start the next season. In other studies it was noted that tobacco plants artificially inoculated with streak virus appeared to recover and to resist further infection, suggesting that such artificial immunization may perhaps become an important practical method of control against certain viruses. The experiment station of the University of Puerto Rico found that in the tobacco strains tested, two recessive genetic characters must be present to give resistance to the mosaic strain used.

Studies of insect control in tobacco plant beds by the Kentucky Station showed that although flea beetles could be reduced by barium fluosilicate better than by any other insecticide tested, far better protection was afforded by using board frames covered tightly with tobacco cloth.

SUGAR-PLANT DISEASES

Chlorotic streak, a sugarcane disease first reported for the State in 1937 and believed due to a virus, has been spreading in the Sugar Belt and planters have been warned by Louisiana Station investigators to guard against it.

The sugar beet leaf spot fungus was found by the Iowa Station not only to live and grow for many months in the soil, but also to be capable of spreading therefrom to the seed and foliage leaves of young plants, with destructive effects on yield and depression of sugar percentage. Crop rotation is thus definitely indicated as an important control measure.

A peculiar root malady of sugar beets observed in the Rocky Ford district was found by the Colorado Station to be due to the fungus *Pythium butleri*. Besides attacking the mature root it can also cause severe damping-off of seedlings. Marked internal damage to sugar-beet roots and severe damping-off was shown by the same station to be caused by *Rhizoctonia*, another soil fungus. The Iowa Station reports a severe case of late canker rot in sugar beets following potatoes, due to the kind of *Rhizoctonia* common on the latter crop. The Minnesota Station, with the Department of Agriculture (B.P.I.), also found that strains of this fungus from badly affected potato sprouts caused decay when inoculated into sugar beets. The Montana Station reports significant progress toward the solution of the major disease hazards of sugar beets in the Billings area.

SUGAR-PLANT INSECTS

The sugarcane borer in small cane has been shown by the Louisiana Station to be very effectively controlled without injury to the plant through the use of cryolite. Furthermore, several years' experience has indicated the value of careful burning of cane trash. Differences in strains or species of the egg parasite *Trichogramma* were found largely responsible for variable control of the borer. The experiment

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station of the University of Puerto Rico found unexpectedly that the percentage of parasitization by *T. minutum* apparently drops suddenly after heavy rains and recovers slowly during ensuing dry weather. Artificial releases of a drought-resistant strain of the parasite showed this reaction even more clearly than the native strain, since insects released ahead of dry weather resulted in very high parasitization of borer eggs within 1 to 2 weeks, while no eggs were attacked in control fields. Introductions of sugarcane borer parasites have also been made by the Puerto Rico Federal Station with the Bureau of Entomology and Plant Quarantine. An outstanding recent event was the bringing into the island of the beneficial Amazon fly, which also is parasitic on the sugarcane borer. Breeding material of this fly was obtained with the cooperation of the British Guiana Government and brought to Puerto Rico by air. This insect has also been forwarded to Florida and Louisiana in an effort to combat the borer not only on sugarcane but also on corn.

The sugarcane mealybug is reported by the Florida Station to have been effectively and economically controlled through submerging the seed cane in cold water for 21 days.

FORAGE AND COVER-CROP DISEASES

Kernel smut of kafir has been studied by the Kansas Station along epidemiological lines. Soil temperature and moisture proved to be interdependent factors in determining infection, apparently conducing to maximum infection.

The fungus smuts of barley grasses, bromegrasses, and wheatgrasses in the Pacific Northwest are now considered, as a result of studies by the Washington Station, to belong to one composite species, probably containing numerous well-defined physiological races. Some 37 susceptible North American grass species are listed, 10 of these hosts being reported for the first time. These facts are important in the selection and breeding of better grasses.

An eyespot disease causing considerable damage to certain selections of the introduced Napier grass was found by the Florida Station to be due to the fungus causing the eyespot disease of sugarcane. Other stock of this grass proved to be immune.

Susceptibility to bacterial stem blight of 53 alfalfa varieties in the field was shown by the Utah Station to cover a wide range, the French and Turkestan strains being very susceptible to this destructive disease and the Ladak variety the least so. Individual plants of all varieties, however, remained free, suggesting the possibility that many resistant strains may be found. Severity was correlated with frost injury.

A red clover seedling blight and blackening of the roots reported by the Kentucky Station to be common in that State was shown to be caused by the same fungus that produces charcoal rot of sweetpotato.

FORAGE AND COVER-CROP INSECTS

The alfalfa snout beetle, a pest of serious import to the production of this crop in New York State, was found by the Cornell Station to succumb in the field to a raisin-shorts-sodium fluosilicate bait. Best results are secured where infested fields are plowed and planted for

2 years to cultivated crops before use of the bait after which the fields may be returned to alfalfa or clover. New seedings of these crops should be protected against migrating beetles by baited furrows.

Poor alfalfa-seed crops in recent years have reduced Utah from its position as one of the leading alfalfa-seed States to the point where it produces but little more than that needed for home planting, total production having fallen recently from over 20 to about 4 million pounds of seed per annum. The Utah Station cooperating with the Department of Agriculture (B.P.I.) in studying the underlying cause, has found that certain insects, especially certain plant bugs, injure alfalfa to such an extent that the plant fails to set seed.

That the important velvetbean caterpillar can be controlled economically and without plant injury by cryolite dust has been recently demonstrated by the Louisiana Station.

The hairy chinch bug, damaging turf on Long Island, can be controlled, as shown by the New York (Cornell) Station, by tobacco dust reinforced with nicotine, by cube dust with rotenone, or by a nicotine-soap spray. The dusts gave consistently better results and caused no burning.

POTATO AND SWEETPOTATO DISEASES

Potato scab, because of its underground habitat, is difficult to deal with, and this, together with its Nation-wide occurrence, places it among the major problems of the potato industry. The conditions favorable or unfavorable to the disease have not been thoroughly understood, but information developed at the Nebraska Station and presented in two research bulletins has thrown needed light on these points. Incidentally, the scab organism appeared to be extremely sensitive to ammonia, being destroyed in soil to which enough urea or other ammonia-producing chemicals have been added. The New York (Cornell) Station reports an experiment in which the tubers of plants sprayed with bordeaux mixture showed marked reductions in scab. The New Jersey Station has found the scab organisms to be variable in their ability to attack susceptible kinds of potatoes. The Minnesota Station studied the relative resistance to scab of 60 seedling potato families as a basis for the selection of breeding stock for use in the attempt to combine high quality, type, and yield with scab resistance, which was found to be heritable.

Potato-seed treatment is generally employed to rid the seed tubers of scab, rhizoctonia, and other diseases. Mercuric chloride solution is extensively used for this purpose. The Maine Station recently discovered that although this chemical gradually lost strength with repeated use, the addition of hydrochloric acid in small amount would greatly retard or prevent this loss of potency, thus resulting in much economy.

Though potato late blight is erratic in occurrence, its inroads under continued favoring weather conditions are more sudden and disastrous than those of any other potato plague. Constant and costly spray protection has been successfully resorted to in many sections, but commercially desirable types of potatoes that will resist the fungus are being sought in order to stop this risk and expense. The Department of Agriculture (B.P.I.) and the Maine and New York

(Cornell) Stations, especially, have worked together in this search. The latter station has found means of building up high virulence in the blight fungus for use in giving supposedly immune or resistant lines of potatoes the severest possible test. Many hybrids have successfully passed such tests. The Maine Station and the Department report the finding of types of resistance in certain existing commercial potato strains that can be transmitted from parents to offspring.

Such soil-borne diseases as scab, rhizoctonia, and *Fusarium* wilt may be effectively reduced by proper crop rotations, according to the results of long tests by the Nebraska Station. In general, long rotations with alfalfa preceding potatoes appeared to give the best results under Nebraska conditions.

Recognition of the new bacterial wilt and soft rot discovered in certain seed-potato growing areas, as mentioned in the last report, led to the almost complete elimination of the heavy losses previously incurred from the use of affected seed in Florida.

Potato virus diseases continue to demand attention. The newly announced blue stem disease appears to be associated with some insect, according to the West Virginia Station, which finds that certain features distinguish it from the usual potato virus diseases. The troublesome potato yellow dwarf virus was found by the New York (Cornell) Station also to be carried by an insect (a leafhopper) harbored in red and other clovers, indicating that growing potatoes away from clover would reduce danger of infection. Evidence indicated, too, that escape may also lie in the direction of breeding. Leaf roll, another serious virus disease, not only produces low yields but renders the tubers of little value due to the resulting net necrosis as demonstrated by the Maine Station, which showed that abnormally severe outbreaks in that State were associated with unusually large populations of the peach aphid, a very efficient carrier of leaf roll. Avoidance of planting potatoes showing net necrosis should serve to reduce the sources from which the malady starts.

Spindling sprout, often known as hair sprout, in recent years has caused very serious losses in fields planted with affected seed potatoes. The gravity of the situation led to the calling of a conference of potato specialists representing 19 States at Baton Rouge, La., in April 1938. The Hawaii Station has conducted grafting experiments tending to show that spindling sprout is not of infectious virus nature but is due in all probability to unbalanced physiological relationships the basis of which remains to be worked out.

Sweetpotato soil rot or "pox" has been one of the limiting factors in producing this crop in Louisiana. In one parish infected fields were almost totally destroyed. In control experiments by the Louisiana Station a remarkable return to normal yields was brought about by applying sulphur at the rate of 700 to 1,000 pounds per acre.

Wilt in sweetpotatoes was reduced from around 30 to 60 percent to 3 to 7 percent, in tests at the Delaware Station, by treating the sprouts with copper or mercury compounds before planting.

Storage rots cause enormous sweetpotato losses. The New Jersey Station, working on materials that might be used to treat the harvested roots, has found several combinations which seem not only to improve the appearance of the potatoes but also to afford considerable protection against both drying out and rot.

POTATO AND SWEETPOTATO INSECTS

Psyllid yellows is the most important insect-caused injury of potatoes in the Rocky Mountain region and a number of stations cooperating with the Department of Agriculture have been investigating it. The New Mexico Station reports that only immature stages of the psyllid feeding on the plant can produce injury, and that all forms of lime-sulphur and dusting sulphurs are effective against the insect, the dusts being least injurious to the plants. The Wyoming Station found that fields planted prior to June 1 suffered less damage than those planted later. The Colorado Station has also presented the results of research on this insect.

The potato flea beetle was a major cause of losses in certain Virginia fields. The Virginia Truck Station tested control methods and got a 60-bushel-per-acre increase in yield (5-year average) where a combination of calcium arsenate and bordeaux mixture had been applied.

The potato leafhopper, causing considerable losses in many seasons and localities, was found by the Ohio Station in 3 years' tests with various materials to be best dealt with by using bordeaux mixture with half the usual amount of lime, higher yields being due, perhaps, to plant stimulation as well as to successful insect control.

Sweetpotato weevils were found by the Louisiana Station to be effectively combated in storage with sulphur or dry lime-sulphur, which acts as a fumigant in airtight spaces. In laboratory tests these insects were easily killed by arsenical and fluorine poisons.

TRUCK-CROP DISEASES

Stem rots (*Sclerotinia* and *Botrytis*) of tomatoes and cucumbers under glass are reported by the Illinois Station to cause losses of 60 to 75 percent of the crops in some commercial greenhouses. In testing materials and methods of control, a thick bordeaux paste gave nearly perfect control, even after the establishment of infection. Studies of the *Botrytis* fungus by the Ohio Station indicated that the stems, foliage, blooms, and fruit of greenhouse tomatoes become infected most readily where moisture remains long on the leaves or where night temperatures are well below day temperatures. Tomato early blight and *Septoria* leaf spot, according to 2 years' trials of the newer copper sprays by the Michigan Station under conditions of light infection, were best controlled by Cuprocide, which also depressed the yields less than 4–6–100 bordeaux. The New Jersey Station finds that tomato mosaic may spread very rapidly in the field, every plant sometimes becoming infected before the end of the season where only a few diseased plants were set out. In one case the fruit set was reduced by 66 percent.

According to the Pennsylvania Station primary infections with tomato collar rot were practically eliminated in 4 years by seed fermentation and mercuric chloride treatment, seedbed soil sterilization, and seedbed and transplant bed spraying. By controlling diseases in the field red copper oxide or copper oxychloride spray increased the yields to 2.5 to 3 times that of unsprayed tomatoes. With respect to copper sprays on tomato leaves, it appears from studies by the Rhode Island Station that copper and lime on the leaf surface

will readily penetrate and induce changes in the cell walls, permitting increased and sometimes detrimental loss of water, substantiating earlier work which showed that copper sprays increase transpiration particularly at night.

For reducing losses from pea root rots the New Jersey Station has shown a heavy application of commercial fertilizer to be the most effective method. On soil cropped to peas for the fourteenth consecutive season and, as a result, so severely infested with root rot fungi that all plants were attacked, applications of 1,000 pounds to the acre of 5–8–5 fertilizer as a side dressing after the peas had emerged gave yield increases of 71 to 103 percent. The fertilizer appeared to delay and decrease the amount of infection and permit a fair crop despite the disease.

The bacterial bean blight, a seed-borne disease, reported by the Louisiana Station as very severe in 1938, was effectively controlled by a seed treatment which gave very striking results, practically eliminating primary infection. A mixture of water, alcohol, mercuric chloride, and acetic acid was employed.

Transmission of common bean mosaic through the seed has been confirmed by the California Station. In resistance tests involving 118 selections from 52 bean varieties it was found that symptom expression may be used as a measure of relative varietal susceptibility. Very promising resistance was shown in many lines. The Idaho Station reports that two new hybrid bean selections resistant to this mosaic have just been introduced to the growers of that State.

With respect to powdery mildew of beans, the Virginia Truck Station found the Idaho, Wisconsin, and U. S. No. 5 mosaic-resistant Refugee varieties to be extremely resistant, a condition inherited from Corbett Refugee, one of the parents of all three. Highly resistant individuals also occurred in the Tennessee Green Pod variety.

The relative susceptibility to bacterial wilt of 37 sweet corn varieties as tested by the New Jersey Station confirmed the fact that Golden Cross Bantam has given the most satisfactory results although too late for best market advantage. Spancross 39 and Early Bancross were the best of the earlier resistant varieties.

With onion production increasing in New York State, the diseases menacing this $2,000,000 crop are becoming increasingly important. During seasons of excessive rainfall onion mildew or blight frequently reaches epidemic proportions. The Cornell Station has shown that a highly important perennial, primary source of infection may be the Egyptian or top-set onion, many plantings of which are left in back-yard farm and home gardens year after year. Proof has been obtained that virulent spores from these onions are carried by air currents and constitute a primary source of disease in the commercial fields. Malachite green dye proved much more toxic to the fungus spores than copper sulphate.

Lettuce yellows, a virus disease, is reported by the New Jersey Station to have been responsible for 80-percent crop losses in certain plantings. Serious infections were often observed in fields maturing in August or early September but not in earlier or later crops. A fine-mesh cloth barrier (without top) proved very effective in reducing infections, more so than eradicating affected plants. The leaf-

hopper which carries the virus seldom flies to any considerable height unless aided by the wind, and where plants can be protected from leafhoppers by such barriers a healthy crop is produced. Tests also indicated that leafhopper control by chemicals may become feasible.

Lettuce drop or watery brown rot oversummers in Arizona by means of the hard, dark-colored "seed balls" (sclerotia) which may remain alive for years. To determine the possible control value of running sheep on infested lettuce fields, the Arizona Station fed sheep approximately 16,000 sclerotia per animal, mixed with lettuce and alfalfa, of which 95 to 99 percent were destroyed. Infested fields pastured after lettuce harvest and planted to small grains for a season have subsequently borne successful crops of lettuce.

Celery pink rot, due to the same fungus causing lettuce drop, was controlled on muck soils by the Florida Station through destruction of the sclerotia by flooding the land for protracted periods or through application of cyanamide to the soil. Control of celery leaf blights is still under study by the Michigan Station, which has found indications that certan new dust combinations may prove better than the older copper-lime treatments. For the present, however, bordeaux or copper-lime dust are still recommended.

The *Fusarium* wilt of watermelons, first reported in the State in 1918 and said by the Virginia Truck Station now to be one of the limiting factors in commercial production, may be effectively combated by using wilt-resistant varieties, such as Hawkesbury, tested or developed by that station and now available. Seed treatment and crop rotation are also valuable. The California Station, after testing seven wilt-resistant varieties originated elsewhere and finding them unacceptable for local conditions, has developed new Iowa Belle-Klondike hybrids sufficiently resistant for profitable production on badly infested soil. Seeds of the wilt-resistant Leesburg watermelon originated by the Florida Station were made available in quantity for the first time in 1938, some 500 acres of this new variety having been planted in Florida.

Muskmelon wilt, due to a *Fusarium* closely related to the one just mentioned, is destructive in certain local areas of Minnesota and apparently spreading. At present, control depends on the use of clean soil and seed. However, the Minnesota Station has developed promising new varieties of early maturity, good quality, and high resistance from a hybrid between the Honey Dew and Golden Osage. Further selection and inbreeding are necessary prior to distribution.

The bacterial soft rot organism of pumpkin in California has been identified by the California Station as one attacking a large number of truck-crop varieties under natural conditions. Several resistant varieties of pumpkin and celery are reported.

Cucurbit anthracnose has been under study by the Iowa Station. Using a new technique for measuring relative resistance, the station found no commercial watermelon, cantaloup, or cucumber varieties with resistance sufficient to be of economic importance, but fortunately it has discovered anthracnose-resistant, edible African watermelons which are being used in further breeding work.

A Chinese cabbage mosaic disease studied by the California Station and prevalent in the central part of the State was found transmissi-

ble by mechanical inoculation and by the cabbage aphid and the green peach aphid.

Cabbage production in many parts of the United States has been virtually saved as a commercial enterprise by the long-continued work of the Wisconsin Station in developing varieties resistant to the yellows or *Fusarium* wilt disease. A recent study has disclosed the fact, of great assistance in the current breeding program, that two types of resistance are present in the All Seasons variety, each behaving in a different manner in inheritance. Yellows has been present in New York for some 20 years and has been steadily on the increase, according to the New York State Station. In a recent hot, dry season losses were as high as 90 percent in some commercial stands. Use of resistant varieties is the only means of insuring a crop. In order to determine the best resistant types for New York conditions detailed test plantings in the laboratory, greenhouse, and field have been made by the station for selection and possible breeding work.

The pepper blight fungus (*Phytophthora capsici*) is reported by the Colorado Station as also causing a serious disease of cucumbers.

Tests on seed fumigation with carbon disulphide by the Florida Station have given preliminary results showing significant increases in the germination of cabbage, cucumber, radish, carrot, and some annual flower seeds. Certain vegetable seeds responded likewise to hydrocyanic acid fumigation, while others were checked.

Spinach- and cabbage-seed treatment has been studied over two seasons by the Virginia Truck Station, comparing 11 materials. Even under especially favorable conditions for seed decay, satisfactory stands of spinach were obtained with 20 to 30 percent less seed than is generally used if treated with 1 to 2 percent of such copper or zinc materials as zinc oxide, red copper oxide, and Vasco 4. Seed treatment was most important when early fall spinach was planted. The same three fungicides were effective for preventing seed decay in cabbage, though red copper oxide sometimes stunted the plants. Use of graphite with treated cabbage seed, particularly, eliminated damage to the seed and drills from friction.

Among "insoluble" copper fungicides for vegetables, the Ohio Station found basic copper chloride, copper oxychloride, and copper ammonium silicate, used in a dust formula, to give such excellent results on cucumbers and muskmelons that they are recommended in preference to bordeaux spray or copper-lime dust. These materials also compared favorably with bordeaux on tomato, carrot, celery, and ginseng.

TRUCK-CROP INSECTS

European corn borer control with insecticides on early sweet corn has been intensively studied by the Connecticut (State) Station in cooperation with the Department of Agriculture (B.E.&P.Q.). Fixed nicotine, rotenone, and phenothiazine were all effective against the first-generation borers whether used as sprays or in dust form. A newly developed dual-fixed nicotine (nicotine tennate plus nicotine bentonite) also gave consistent control.

The corn earworm, the most destructive sweet corn insect and very difficult to control, was reduced by 53 to 83 percent through removal

of the corn silk during 3 years' trials by the New Jersey Station at costs to growers of only one-third to one-eighth of a cent per dozen ears. The New York State Station also reports favorable results with this method, while the Kentucky Station got good control through clipping off the ear tips after pollination.

Lima beans for canning were almost completely destroyed late in the season by corn earworms over several hundred acres in Tennessee, where the station reports that when baits broadcast over the fields were tried, best results were obtained with cottonseed meal plus 5 percent of sodium fluosilicate, although main dependence should be placed on corn as a trap crop.

The Mexican bean beetle has become a pest of major importance in South Carolina, where the station reports that nonpoisonous rotenone sprays and dusts proved unusually effective in all tests and are recommended instead of arsenicals.

In bean thrips control tests by the California Station with a number of the newer dust preparations, the pyrethrum-sulphur mixture gave the most adequate results. Elimination of the weed source of infestation was found most important. Overhead irrigation sometimes held thrips in check.

To combat the lima bean pod borer and related insects, a large number of oriental fruit moth parasites have been released in Puerto Rico, through the cooperation of the Bureau of Entomology and Plant Quarantine with the Puerto Rico Federal Station.

The cowpea curculio is a serious pest of garden and canning cowpeas, particularly as no mechanical means has yet been developed for separating out wormy from sound peas. Study by the Georgia Station showed that the adult hibernates in nearby broomsedge, and also breeds in a native wild bean. The suggested use of susceptible cowpeas as trap crops for resistant varieties may give partial control.

The pea aphid creates a serious and widespread problem through its direct damage to the crop and its transmission of mosaic. In extensive preliminary tests of control methods by the New Jersey Station, nicotine applied as a spray proved more efficient than other insecticides tried. Dusting by airplane proved less efficient than ground dusting. The Maine Station has recently used for pea aphid control highly concentrated insecticides with rotenone or nicotine in a liquid base, such as a light, highly refined oil. Rotenone thus applied when the peas are in bloom remained effective for about a week, and under Maine conditions a second treatment may not be necessary.

Pea weevil control methods developed by the Oregon Station in cooperation with the Department of Agriculture (B.E.&P.Q.) are said probably to have saved the $3,000,000 canning-pea industry of the State. Timely applications of rotenone-containing dusts are effective in nearly or quite eliminating this serious pest, and a hooded duster permits satisfactory applications even in the wind. The same Bureau cooperating with the Idaho Station found rotenone dusts continuing to be highly effective against pea weevils when used at proper stages. Use of a moldboard plow equipped with disk colter to bury infested peas 6 or more inches in the soil was followed by little weevil emergence.

For squash borers, very destructive to squashes and pumpkins, the New York State Station recommends use of either arsenical or nicotine sprays, preferably the latter, under high pressure, directed especially at the eggs near the base of the plants. Control of this pest by the Colorado Station was carried out through hand picking, traps, and dusting with dry Pyrocide.

In tomato fumigation tests under glass, the Colorado Station found methyl bromide to show considerable promise for control of various greenhouse pests, causing little or no damage even to the most tender plants. Trials with fumigants against pinworm infestations of tomato fruits proved that hydrocyanic acid gas cannot be used, because of fruit injury. The same was true for ethylene dichloride and carbon tetrachloride mixtures but methyl bromide and carbon dioxide proved harmless. The California Station has recently reported on the life history of the corn earworm, also a tomato pest, and of a closely related but less harmful form.

The cabbage maggot, one of the major pests of cabbage, cauliflower, and radish, has been successfully combated by the New York State Station through use of calomel applied as a suspension around the young plants, as a dust, or as a coating on seed. The Rhode Island Station reports superior control with mercuric chloride, while the New Jersey Station finds metallic mercury-bentonite, or calomel mixtures about equal in effectiveness against it and superior to mercuric chloride. For common green cabbageworm control, derris dust was found by the New York State Station to be an effective substitute for arsenicals. With respect to three species of green cabbageworms, the Virginia Truck Station tried repeated applications of derris, cube, and pyrethrum dusts with good results.

The eggs of the harlequin bug, also a cabbage pest, are parasitized by an insect (*Oöencyrtus*) the biology of which has recently been reported upon by the California Station.

The pepper weevil is reported by the Florida Station to be a potentially important pest in that State, and observations on its life history, host plants, and control, and descriptions of its several stages are presented.

The spinach leaf miner, sometimes causing serious losses, can be largely eliminated, the New Jersey Station finds, by use of derris root dust. It was found, however, that these insects live on plantain and lambsquarters, and that where these weeds are kept down the damage to spinach is slight.

Thrips injury to the tops of bunching onions has caused serious discrimination on the part of buyers. The New York (Cornell) Station has found that rotenone or naphthalene dusts gave satisfactory protection and has developed a suitable muck-land dusting machine to apply them. Onion, flower, and tobacco thrips were observed by the Louisiana Station to injure various garden and truck crops. Failure of nicotine sprays to kill tobacco thrips was corrected by adding potassium hydroxide. Karaya gum also markedly increased their effectiveness.

The garden centipede, according to California Station tests, can be successfully combated by flooding fields in summer for several days. Carbon disulphide also proved very effective.

ORCHARD DISEASES

Apple scab studies by the Wisconsin Station have produced information as to the nature of varietal resistance and susceptibility to this almost universal disease of great potential value in breeding for better fruit. It was also found that the scab fungus is variable in ability to attack different varieties and that the sexual stage constitutes an important source of these variations which fruit breeders must consider.

Pear scab is akin to apple scab and at times difficult to handle. The Oregon Station with the Department of Agriculture (B.P.I.) has shown that the disease is carried primarily from the twigs, where it overwinters, to the fruit, and early sprays directed against this twig infection are essential.

In its studies of the apple blotch disease, so troublesome in the South, the Oklahoma Station found that wind-blown rain may spread it as much as 250 feet and that it may be carried by dry leaves as far as a mile—facts of importance for community control.

Xylaria root rot, a seriously destructive disease of apple trees in the Shenandoah-Cumberland fruit section, has been found to persist actively in the soil for at least 2 years in tests by the West Virginia Station. It was also found that out of hundreds of named and seedling rootstocks tested none was immune to the fungus.

Fire blight, the first bacterial disease of plants to be recognized and still one of the most destructive pear and apple diseases because of the difficulty of control, is being subjected to continued intensive study in several States. The Arkansas Station has elucidated the influence of different weather factors on the length of life of the fire blight germs. Field tests by the New York (Cornell) Station proved that various chemical sprays and dusts applied during the blossom period reduced blossom blight without reducing the set of fruit or injuring fruit, foliage, or bees. Although a number of the newer copper sprays gave promising results, bordeaux mixture (1–3–50) and copper-lime dust (20–80) proved most effective.

Some of the work on newer fungicides has already been mentioned. In addition an encouraging report from the Michigan Station states that with use of wettable sulphur or several of the newer copper spray materials against apple scab, the loss of leaves was less than with ordinary lime-sulphur. The New York (Cornell) Station also found wettable sulphur sprays less damaging to apple yields in 5 years' tests, trees sprayed all season with such material yielding some 4 bushels more per tree than those sprayed with lime-sulphur. The Illinois Station found the newer "insoluble" copper compounds effective for apple scab and blotch and productive of less injury than bordeaux but not yet safe enough to be recommended for general use. Among a number of the newer types of commercial wettable sulphur, this station found two which gave good scab control when applied sufficiently often during severe test periods. The Tennessee Station issued a comprehensive and practical spray bulletin based on studies of methods, materials, and equipment adapted to State conditions. The facts learned in several years' work by the Virginia Station have saved orchardists much through lowered costs as well

as in reduced losses from spray burn and diseases. Studies of 24 lots of commercial wettable sulphur by improved microscopic methods provided definite comparisons by which growers can choose wisely between them. Comparisons of copper-containing materials marketed as substitutes for bordeaux showed none equal in effectiveness, while the majority caused far more burning. The working out of cheap methods of preparing wettable sulphur at home has tended to bring large savings to the farmers. The Ohio Station found lime-sulphur more effective in apple scab control than wettable sulphurs, which, however, are to be favored at times because they injure foliage less and produce better finish on the fruit. The Pennsylvania Station, also searching for an apple spray, both safe and effective, found dilute lime-sulphur fortified with high-grade wettable sulphur promising, while copper phosphate with lime and bentonite proved one of the least injurious of the copper sprays tested.

Fruit-storage troubles have been reduced tremendously in recent years through research. The Iowa Station has reported the results of 11 years' study of soggy break-down in apples which will be an important guide to future storage management. It proved best to store all susceptible varieties tested at 36° F. Water spot, a type of rind blemish causing considerable loss in navel oranges, was found by the California Citrus Station to be a noninfectious condition which can be reduced by certain precautions in orchard management and in fruit handling.

Growers of cherries and peaches are fighting destructive diseases more successfully and economically than ever before with the help of experiment station research. That peach leaf curl can be controlled by the use of copper and sulphur fungicides at from one-half to one-third the strengths formerly recommended, was reported by the Virginia Station.

Discovery by the Delaware Station that peach nursery stock grown in arid regions does not carry the bacterial spot disease points out a way to avoid introducing this trouble into new plantings with nursery trees. The root knot nematode, destructive on peaches in the South, is resisted to a surprising degree under Georgia conditions by descendants of a red-leaved peach seedling developed at the New Jersey Station. Nematode-resistant almonds and plums have been found and are being further developed by the California Station. The peach mosaic disease which State and Federal agencies are trying to eradicate is being attacked in Colorado by eliminating from the danger area all plums that are symptomless carriers of the virus.

The cherry leaf spot disease has been found by eastern growers to be responsible for more severe damage to this orchard crop than any other single factor, often causing complete loss of foliage, with the resulting injury to current and succeeding fruit crops. Five stations have reported during the year on experiments aimed at better methods of control with less injury. The Wisconsin studies covering 18 years throw much needed light on the nature and behavior of the disease. In many years' trials, comparing some 16 fungicides, bordeaux was found superior against this trouble. In recent work with newer types of materials by the New York State Station, certain sulphur sprays appeared to give great promise as substitutes for

bordeaux, while the Ohio, New Jersey, Illinois, and Michigan Stations report that certain types of fixed copper compounds have advantages over bordeaux.

ORCHARD INSECTS

The codling moth is probably the subject of more widespread study and inventive effort in experiment stations from the Atlantic to the Pacific than any other fruit pest. Each year brings new and helpful information from these sustained efforts. The Washington Station, supplementing its extensive experiments with the inverted spray mixtures referred to in the last report, has shown increased codling moth control and easier removal of spray from harvested fruit by the use, in late applications, of 6 pounds of lead arsenate per 100 gallons of spray, employing the inversion method. Zinc sulphate proved useful in controlling degree of inversion and both cryolite and calcium arsenate proved effective as inverted sprays, thus giving hope of success with materials less objectionable than the common lead arsenate. The Ohio Station has summarized 10 years' investigations of codling moth activity and control methods under Ohio conditions. The Pennsylvania Station, studying the effect of fruit growth on spray protection, found indications that codling moth cover sprays should be applied at closer intervals during the early part of the season than later. The Illinois Station issued carefully worked out tables for growers to use in determining quickly and accurately the amounts of different materials required in orchard spraying or dusting. The Connecticut (State) Station reported good results over a period of years from a lead arsenate-lime-fish oil orchard spray used against insect pests and also certain diseases.

In New Jersey, fixed nicotine for codling moth control gave superior fruit finish and but slight leaf injury and as compared with lead arsenate and lime or lead arsenate with oil it appeared not to suppress beneficial insect parasites of the codling moth as much as the arsenate mixtures. In the case of the arsenical sprays, addition of oil at egg-laying peaks was found to improve the control, although producing more injury than when lime and milk were added.

Reports on bait and light traps coming from the Pennsylvania, New York (Cornell), Virginia, and New Mexico Stations confirm the work of others and indicate that these have real value as supplements to, but not as substitutes for spraying. Trap improvements are resulting in greater effectiveness with lower costs. In 10 years' trials, plain cane sirup in water with 0.2 percent of sodium benzoate proved the most attractive codling moth bait tested in New Mexico. Beta-naphthol-treated bands placed around trunks to kill overwintering worms continued to show up well in tests reported from New Mexico, Kansas, Michigan, and Virginia.

In a 10-year study of apple leafhoppers, the Virginia Station tested 58 apple varieties as to damage from their attack. The results indicated injury to be almost absent from Stayman Winesap, Winesap, and Jonathan but to be pronounced on Early Harvest, Yellow Transparent, and Albemarle Pippin.

The pear midge often causing losses of 25 to 50 percent of the fruit in unprotected New York orchards can now be controlled by proper

use of nicotine or summer oil emulsion as worked out by the New York State Station over a period of 11 seasons.

The apple root borer has been effectively controlled in further tests by the New Mexico Station when either a gasoline solution of paradichlorobenzene or carbon disulphide emulsion has been applied to the soil in trenches.

The scurfy scale has become extremely destructive to apple and other fruit trees in one limited New York area from which it is apparently spreading in all directions. The New York State Station has found three different insecticide-oil combinations to be safe and effective against it if applied before growth starts.

The oriental fruit moth is one of the worst orchard pests in the East, particularly on peaches. For its control the Pennsylvania Station tested out some 40 chemicals to be employed as attractants for use in traps, oleic acid (U. S. P.) and terpinyl acetate proving most effective. The Ohio Station reports that a parasite (*Macrocentrus ancylivorus*) of the oriental fruit moth introduced from New Jersey has become the commonest and most effective agent of biological control in Ohio. The Connecticut (State) Station likewise notes definite curtailment of fruit moth damage in orchards where parasites collected by the Department of Agriculture (B.E.&P.Q.), have been introduced.

The peach borer, another destructive pest, has attacked cherry trees in Colorado, but the station found that 100-percent control could be secured with paradichlorobenzene.

Thrips have ruined many crops of prunes in the Pacific Northwest. A long program of experiments by the Oregon Station has now developed a spray program, timed to the activity of the insect, which has materially reduced such losses.

Control of the mealy plum aphid was worked out in 9 years by the California Station, which found winter applications of 2-percent coal-tar-distillate emulsion of the paste type to be more efficient than other methods.

Citrus growers in both East and West are aided in the solution of insect problems by their respective experiment stations. The Florida Station found a speckled condition on mature oranges hitherto confused with the melanose disease to be in reality due to rust mite injury to the young fruit. The same station found both the rust mite and the purple scale controlled by wettable sulphur added to other sprays.

In the introduction of potentially useful parasitic insects that will suppress the citrus mealybug and various scales and in the study of their habits the California Citrus Station has continued to make headway. Extensive studies on parasites from all over the world belonging to the genus *Coccophagus* were published during the year. One member of this insect group from Australia has proved very effective in helping to keep down the citrophilus mealybug in California. Among the parasites on which this station has also recently reported are three common North American species of *Trichogramma* which successfully attack eggs of many species of insects. After some 40 years of searching, a true internal parasite for the citrus red scale has been found by the California Station.

It may also be noted that the Puerto Rico Federal Station with the Bureau of Entomology and Plant Quarantine has also introduced many useful parasitic insects into the islands from other parts of the world—among them a Fiji beetle, the only known effective natural enemy of the banana root borer.

SMALL-FRUIT DISEASES

Anthracnose of black raspberry is largely responsible for marked decline of the industry in northeastern Kansas. The Kansas Station finds this disease can now be held in check by a dormant spray of strong lime-sulphur which destroys the overwintering stage.

Septoria leaf spot of the blackberry family presents a major problem in different parts of the United States, and an attempt is being made to breed varieties resistant to it. The perplexing experience that berry types resistant to *Septoria* in one section are susceptible in others has now been explained by the finding of the Oregon Station that there are, in different regions, two different kinds of *Septoria* on blackberry.

The destructive red-stele root disease of strawberry, reported as a rapidly spreading recent introduction, appears not to affect the Pathfinder variety introduced by the New Jersey Station. According to results obtained by the Utah Station, two other soil-borne (fusarial) infections of strawberry appear likely to do less damage where the soil can be made acid enough to slow down the growth of these fungi.

Strawberry leaf spot control has been reinvestigated recently by the Louisiana Station, which found bordeaux mixture to be an effective eradicant largely by reason of its ability to give off minute quantities of copper into films of water on the leaves.

SMALL-FRUIT INSECTS

The Western Washington Station has shown that the spread of mosaic, the most destructive disease of red raspberry, is proportional to the number of aphids present, while the Utah Station has reported no less than 12 different kinds of aphids on brambles in the Northwest—3 of them previously unknown.

The biology and life history of the oblique-banded leaf roller, which infests both green and ripe dewberries in Utah, has been studied as an aid in developing effective means of control.

Strawberry crown borers cause serious damage. Detailed studies by the Kentucky Station have revealed that their increase can be stopped by digging plants for new patches before March, setting them at least 350 yards away from old infested areas so that the beetles (which do not fly) cannot crawl to them, and eradicating nearby plants such as wild strawberries and cinquefoil, which also harbor these pests.

Sucking bugs which infest strawberries in central Florida have been found by the station to be partially controlled during the fruiting season by a fungus infection active during cool, moist weather.

Cranberry bogs in the East damaged by the blunt-nosed leafhopper are now being successfully protected by airplane applications of

pyrethrum dust put on according to a program worked out by the New Jersey Cranberry Station.

Phylloxera-resistant grape rootstocks for heavy soil types have been successfully developed by the California Station.

ORNAMENTAL-PLANT DISEASES

The rose stem and graft canker fungus is shown by the New York (Cornell) Station to be a wound parasite controllable by removing diseased parts. Rose anthracnose records are extended by the Oregon Station and the Department of Agriculture (B.P.I.) to include stations in North Carolina, Oregon, Michigan, and Tennessee. In the Portland, Oreg., section, where this disease is prevalent, sulphur dusting in a large commercial rose planting was apparently responsible for its elimination. Rose black spot control measures, according to work by the Arkansas Station, must include not only removal of all rose refuse, but also the destruction of living leaves clinging to the plants. Two years' tests were unfavorable to mulching. Work by the New York State Station indicated that Cuprocide 54 (2 ounces to 50 gallons of water) caused no foliage injury, and with ⅛-percent emulsified cottonseed oil added gave efficient control of rose black spot and mildew.

A gardenia canker and gall disease in California was found by the California Station to be due to *Phomopsis gardiniae*, which is described as a new species of fungus apparently confined to a single host plant but of rather wide distribution.

Iris leaf spot (*Didymellina*) infections were substantially reduced in experiments by the New York (Cornell) Station through use of bordeaux or flotation sulphur with spreader. Sulphur dust was less effective than an equal number of spray treatments.

Dahlia gray mold due to *Botrytis cinerea* has been intensively studied by the Utah Station and shown to parasitize the vegetative parts and roots of this plant.

A rocket larkspur bud and stem rot of bacterial origin is described by the California Station as prevalent in that State. All species and varieties of delphinium tested proved susceptible, and potato tubers and carrot roots rotted promptly on inoculation. Seed treatment for 10 minutes in hot water (50° to 55° C.) resulted in healthy plants.

A foot rot of China-aster, annual stock, and Transvaal daisy, found to be due to the fungus *Phytophthora cryptogea*, is described in a joint report from the California and Missouri Stations as favored by excessive moisture, poor soil drainage, and cool weather. The fungus proved pathogenic to many ornamental and vegetable plants. No resistance to the foot rot was noted in any commercial China-asters tested, which included some resistant to *Fusarium* wilt.

A rot of ornamental cacti is reported by the Texas Station as due to a mold fungus (*Aspergillus alliaceus*), which on inoculation also caused decay of several mature fruits and vegetables, probably the first record of this fungus causing a decay of cultivated plants in the United States. In a small test with bordeaux, spraying both plants and soil gave promising results.

Since damping-off of seedlings of ornamentals is a problem in propagation from seed, the Massachusetts Station undertook a study

in which some 112 kinds of plants were involved. In sterilized soil diluted with washed sand, seedling growth was satisfactory, and there was no increase of the disease. Soil treatments proving good for one species were not always so good, or were even injurious, for another. Among the many materials tested which controlled damping-off was calcium cyanamide, and more use of this treatment was suggested when the necessary delay between soil application and seeding is not objectionable. Ammonia also prevented the disease and, as used, was harmless to most species.

The begonia leaf blight nematode is reported by the Massachusetts Station to be a serious menace to commercial begonia culture. All stages of the pest were killed by submerging potted plants in water at 115° to 123° F. for 1 to 5 minutes, depending on the temperature. Treatment of healthy leaf cuttings from infested or unfamiliar outside sources is recommended.

ORNAMENTAL-PLANT INSECTS

Fumigants and other insecticides for ornamentals under glass have been tested extensively by the Colorado Station. Methyl bromide gave 100-percent kill of a mite on African-violet, the bulb mite on lilies, red spider on verbena and hydrangia, and mealybug on coleus without injury to the host plants. As to the chrysanthemum midge, Pyrocide and talc (1–9) dust applied every second day for 6 weeks prevented the appearance of new galls. Two applications of this dust each week also gave 100-percent control of the onion thrips and leaf tier on chrysanthemums, and 99-percent control of the green peach aphid on snapdragons.

Improved control of red spider on a number of greenhouse crops is reported by the Illinois Station through use of sulphur and cyclohexylamine derivatives. Great variations in the susceptibility of this pest to certain sprays were correlated with the species of plant infested. Selocide and C. P. 100 were most successful for red spider on roses in the greenhouse. Karaya gum increased the toxicity of sprays for this pest.

TREE DISEASES

The Dutch elm disease, a serious threat to this important shade tree, is being studied not only by the Department of Agriculture but also by experiment stations in a number of States. Inasmuch as this disease is spread by insects, the New York (Cornell) Station has studied and listed the various species found in elms, with special reference to their potential ability to transmit the responsible fungus parasite.

Tree-wound dressings are important in orchard and shade-tree work. The Ohio Station, in extended tests, has found asphaltum superior to any other materials thus far tried, in most instances admitting less rot and promoting faster healing. A study of preventive treatments for damping-off disease control in forest nurseries by the Wisconsin Station indicated sulphuric acid to be the cheapest and one of the most reliable soil disinfectants when properly employed.

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TREE INSECTS

Depredations of insects on shade and wood-lot trees, and on wood products, are being given more attention of late. Armyworms on elms, according to the Oklahoma Station, can be controlled with increasing effectiveness by adding molasses to a bran and arsenic bait. Cankerworms and other leaf-eating insects attacking trees can be controlled better in autogiro or airplane dusting, the New Jersey Station finds, if an oil such as fish oil is added to the lead arsenate used.

The palm leaf miner that spoils palms and palmettos for decorative purposes in the South has been studied by the Florida Station, no less than seven species of insects having been found to be natural enemies of this pest.

Bark beetles of the genus *Ips* have been studied by the Minnesota Station, which finds control work carried out during winter to be useless. However, if done between June and October when the broods are young, the removal and treatment of infested trees by stripping the bark, putting the logs in water, scorching the bark, or burning (if the material is of no value) all proved to be useful combative measures.

Carpenter ants seriously curtail the life of telephone poles in Connecticut. The New Haven Station finds, in a 4-year test, that creosote injected forcibly into the top of an ant cavity will eliminate the colony from the pole and repel new invasions. Termites, presenting an almost universal problem but particularly so in the Tropics, are being studied at the experiment station of the University of Puerto Rico, which finds sapwoods ordinarily to be susceptible while heartwoods are resistant to attack by the West Indian dry-wood termite. Gummy and impregnated, fine-grained cypress heartwood is apparently immune, while gummy southern pine heartwood proved surprisingly resistant though the less gummy types were readily attacked.

MISCELLANEOUS DISEASES

The bacterial crown gall disease of many plants has long been studied by the Wisconsin Station, which has found that growing the germs in suitable media in time destroys their capacity to induce the disease. On the other hand, when grown on slightly different media these bacteria retained their pathogenicity for 7 years. Further, the similarity of the growth-stimulating effects induced by the crown gall organism to those of plant hormones has been confirmed.

The *Phymatotrichum* root rot, long studied by the Texas Station, is now known to attack some 1,708 different kinds of plants, although monocotyledonous plants are immune. Extracts from roots of monocots were found to be potent in preventing growth of the fungus. The inhibitory material was obtained from several species including onion and Johnson grass and it is concluded that such immunity is due at least in part to the presence of this substance in minute quantities. The New Mexico Station finds root rot to be more of a problem for trees when growing in soils high in alkali. Barnyard manure, sulphur, sulphuric acid, and copper sulphate, applied to the soil, gave promising results. The Arizona Station has developed a

method of producing barriers against the spread of root rot through the soil by injecting chemicals to a depth of 4 feet or more. The practicability was demonstrated of detecting pecan trees slightly infected with root rot long before easily recognized symptoms are apparent, making possible the treatment of trees in the first stages, with correspondingly greater success. The pecan showed great tolerance to ammonium sulphate or phosphate, and sulphuric acid used in soil treatment. For the southern root rot fungus (*Sclerotium rolfsii*), the Florida Station finds dilute solutions of organic mercury salts extremely toxic.

Damping-off, affecting most kinds of seedlings, has been under continued investigation at various stations. The Illinois Station found it important throughout the State with perhaps 80 percent due to *Pythium* and 15 percent to *Rhizoctonia*, more injury being produced before than after the seedlings come up. Other soil organisms were found to have much to do with the incidence of damping-off, in some cases accentuating and in others seeming to check the trouble. Only moisture and soil acidity appeared directly to affect control by seed treatment with cuprous oxide, organic mercurials, or zinc oxide. Soil treatment was sometimes required in addition to seed treatment, with precautions against recontamination. Where special postemergence treatments were necessary, applications of weak bordeaux to the seedlings at soil level gave nearly perfect control. The station has published detailed recommendations for damping-off control for special conditions and crops. The Connecticut (State) Station, in further tests with sand cultures for producing seedlings relatively free from damping-off, has found it generally possible to use fairly clean sand as it comes from the pit, without washing in hot water as previously recommended.

For hop and onion downy mildews, the California Station has found a relatively new type of spray, rosin lime-sulphur, the most effective fungicide thus far tested.

A peppermint and spearmint anthracnose or "leopard spot" is reported by the Indiana Station as causing significant losses in that State. The fungus overwinters on infested mint debris and is introduced into new fields on infected plants. The Michigan Station also describes this disease and the *Verticillium* wilt besides, and presents control recommendations.

Two distinct *Cercospora* leaf spot diseases of peanuts, destructive apparently wherever peanuts are grown in the United States and formerly confused with each other, were found by the Georgia Station to have distinctly different life histories and to differ in the varieties chiefly affected, facts of importance in developing control measures.

Coffee root rot, the most serious disease of this crop in Puerto Rico, is now considered by the experiment station of the University of Puerto Rico to be due to the fungus *Rosellinia bunodes*. The factors favorable to the disease have been studied. The disease of coffee shade trees known as mal de guaba, very important because of its rapid spread, has also been given attention by the station, but as yet no organism has been found associated with it.

Several wilt-producing species of *Fusarium* have been found by the Florida Station to be able to produce new strains that can induce wilt in other species of plants than those from which they come.

Diplodia strains isolated from several economic host plants were found by the Florida Station to be physiologic forms of one fungus species, rather than separate species.

Modification of the concept of parasitism and immunity has resulted from work by the Wisconsin Station and the Department of Agriculture (B.P.I.) on the effect of water-soaking of plant tissues on bacterial invasion and spread. These studies may also throw light on the overwintering of certain plant parasites, and modify present theories of applying sanitary and eradicative measures for disease control.

Mushroom houses may be rid of diseases and weed fungi, the Pennsylvania Station has found, by fumigation with formaldehyde or burning flowers of sulphur, with tight sealing, supplemented by drenching floors and spraying with a fungicide. For killing harmful fungi in compost, heating to 130° to 140° F. was found necessary. Sanitary precautions and management methods are discussed in a station bulletin on mushroom diseases based on such research.

MISCELLANEOUS INSECTS

Japanese beetles continue to command the attention of various State stations as well as of the Department of Agriculture. As a new control measure, the New Jersey Station reports successful results from the use of an electrostatic field for the destruction of the grubs and eggs in the soil, provided, however, that living plants are not involved, since any soil temperature high enough to insure good insect kill injured the plants.

The grasshopper scourge has also continued under study by many stations. Among others, the South Dakota Station reports encouraging results on the control of both grasshoppers and blister beetles. This station, as well as the Kansas Station, has disproved the claim that Epsom salts will kill grasshoppers, and has shown that the burning of vegetation, or stubble, will not kill their eggs. Plowing of land infested with grasshopper eggs was, however, shown to prevent the hatched young from reaching the surface, provided the eggs are buried at least 4 inches deep and the soil has become packed. Disking and harrowing of infested soil, preferably in the fall, is also effective. After emergence, repeated application of poison baits is the chief reliance. According to the Illinois Station, poison baits containing lubricating oils have proved (1934–37) most practical and effective in that State, and are recommended. The Oklahoma Station reports success with cheap lubricating oil as a moistening agent for poison baits and has demonstrated that such bait can be spread evenly and rapidly by airplanes equipped for dusting cotton. Standard bran, straight bran, and straight sawdust mixtures were also compared, the first giving the best kill but with the second nearly equaling it. The effectiveness of the straight sawdust bait was low. Ground cornstalks and cobs were found effective by the Nebraska Station in sodium fluosilicate baits. The Montana Station found that poisonous baits do not endanger livestock if spread correctly and if care is exercised in storing and discarding unused portions.

For Mormon cricket control, Montana Station investigations have yielded preliminary results that may allow for better timing of dust applications. These applications were most effective at relatively

high humidities and temperatures. To show the importance of these insects, the Colorado Station reports that in 1938 a total of over 21,000 Colorado farmers used bait against Mormon crickets and grasshoppers on at least 2,500,000 acres of croplands, at a cost of over half a million dollars in addition to the Federal funds used. It is said that these efforts protected more than 4,750,000 acres of crops, the results netting a saving to the State of upwards of $11,000,000.

The camel-back cricket, not previously reported as a pest, has been found by the Oklahoma Station to be a major problem over much of the State. Poison bait is reported to have given good control.

June beetle (white grub) control has been further investigated by the Iowa Station. A survey was conducted to determine the relative distribution of the three species found in the State. Field tests showed that paris green, acid lead arsenate, calcium arsenate, and sodium fluosilicate, each diluted with bentonite, are effective in the descending order named. Grub damage to pastures and various cultivated crops and also occasional injuries to nursery stock are reported.

Flax worm control now becomes a possibility through crop rotation, according to work by the Oregon Station. This pest feeds on the terminal buds of flax, thereby ruining the crop for fiber purposes.

Parasites and predators continue to have increasing applications in crop-pest control. The Puerto Rico Federal Station, cooperating with the Bureau of Entomology and Plant Quarantine, reports the introduction of eight species of coccinellid beetles, predaceous on scale insects, from South America and southern Caribbean islands. Successful colonization is already evident, and two of these beneficial coccinellids were sent to Florida for colonization there. The beneficial insect. *Hambletonia pseudococcina*, introduced from Hawaii to parasitize the pineapple mealybug, has also been recovered and is apparently successfully established in Puerto Rico. The same station has introduced the coconut thrips parasite (*Dasyscapus parvipennis*) and several predators of the coconut scale (*Aspidiotus destructor*) from Trinidid.

The experiment station of the University of Puerto Rico reports the development of greatly improved methods for importation and release of a wasp parasite (*Larra americana*) of the mole cricket, said to be one of the most serious insect pests of plants on the island. Other introductions of beneficial insects have been made, notably that of a coffee leaf miner parasite collected in Guadeloupe.

ANIMAL PRODUCTION, PRODUCTS, DISEASES, AND DISORDERS

CONTENTS

Constant shifts in livestock operations and systems of farming are required to keep abreast of changing conditions. In order to keep

pace with these changes and maintain a satisfactory status of production new information is constantly being sought to improve present methods and concepts of breeding, rearing, feeding, and care of livestock, and to improve the quality of marketable livestock products. Examples of recent findings in these fields of research are given in the following pages.

NUTRITION

An economically sound livestock industry is primarily dependent on the proper feeding of healthy animals having the inherent capacity to efficiently transform feed energy into marketable livestock products.

A current trend in animal-nutrition research is toward the cataloging of all the essential factors in nutrition, both organic and inorganic, the study of their distribution, physiological behavior, and interrelationships, and the expression of the optimum levels of these factors in the ration at all stages of the life cycle.

Preservation and use of roughages.—Current research in silage production deals not only with improved methods and the use of various preservatives in ensiling the more common silage crops but also with new silage crops, including many legumes and grasses which have been used heretofore to a very limited extent for this purpose.

A cooperative survey by station and other workers of methods and results of using legume and grass silage on a large number of farms in the Northeastern States and Virginia showed that a great variety of plants was being extensively ensiled. Molasses was most generally used as a preserving agent, while phosphoric acid or a mixture of hydrochloric and sulphuric acids (A. I. V. process) were occasionally used. Such silage was fed primarily to dairy cattle, but in some instances to beef cattle, horses, sheep, swine, and poultry.

The Wisconsin, Michigan, and Ohio Stations have each shown that the stage of maturity and dry-matter content of legumes and grasses are very important considerations in silage making. Relatively mature material produced unpalatable silage of low carotene (the precursor of vitamin A) content. Fresh green material containing only 18 percent of dry matter lost a high percentage of the original weight, including a large amount of dry matter in drainage juices at ordinary silage pressure.

The New Jersey Station concluded that the criticism of timothy hay as a feed for dairy cows does not apply to timothy silage which was palatable and relatively high in protein and carotene content. This station also successfully ensiled a mixture (3:1) of green corn and carrots, including tops, that was palatable, maintained milk production, and materially increased milk color as compared with an ordinary winter ration. Within a dry-matter range of from 30 to 40 percent, alfalfa, soybeans, and timothy were successfully ensiled either with or without molasses at the Vermont Station. This station, in comparing the digestibility of these silages with hays from the same source, showed that artificially dried hay slightly excelled in total digestible nutrients, followed in order by molasses silage, untreated silage, and sun-cured hay. In order of their vitamin A potency, silages assayed by the Nebraska Station ranked: A. I. V. corn, molasses corn, ordinary corn, and soybean silage. The milks

produced when each of these silages was fed to dairy cows as a sole roughage ranked in the same order of vitamin A potency as the silages. Oats and peas were satisfactorily ensiled in a trench silo at the Alaska Station during late August when rainy weather did not permit the curing of hay. Replacing approximately 60 percent of the normal allowance of hay for dairy cows with such silage gave satisfactory results.

The New Jersey Station showed that A. I. V. corn silage lost approximately 20 percent of its original carotene content during 5 months' storage, while very slight carotene losses occurred in A. I. V. alfalfa silage over a like period. Regular corn silage lost carotene very rapidly even when stored in vacuo in the dark at 0° C. Alfalfa silage preserved with phosphoric acid sustained greater loss of carotene than molasses-alfalfa silage at the Pennsylvania Station.

Nutritional characteristics of roughages.—Mountain meadow-hay plants analyzed by the Colorado Station were found to have a similar fodder analysis to nonleguminous plants grown in other regions. They supplied adequate amounts of minerals for animal subsistence and were reasonably satisfactory sources of vitamins A, B_1, and G. A study of the seasonal influence on the vitamin A content of blue grama range grass by the Arizona Station showed that samples collected in August (early-grown stage) were twice as potent in vitamin A as September samples and 100 times as potent as November (mature) samples.

Palatability tests of pasture grasses at the Massachusetts Station ranked them as follows: Timothy, redtop, orchard grass, sweet vernal grass, Rhode Island bent, Kentucky bluegrass, and sheep fescue. These preferences checked closely with nutritive value based on composition analyses. This station also showed that the vitamin activity in the corn plant varied with stage of maturity. Vitamin A increased as the plant approached maturity and then declined rapidly after maximum growth was attained; vitamin C declined with advancing growth, and only traces of vitamin D were present in fresh immature and in ripe material.

The Texas, Pennsylvania, and New Jersey Stations agreed in their findings that dried alfalfa stored at ordinary temperatures loses carotene very rapidly during the summer months, from 40 to 50 percent in 3 months, while carotene destruction was relatively slight during winter storage. Alfalfa meal stored for 12 months at room temperature lost 80 percent of its carotene content in contrast to an approximate 28-percent loss for samples stored at from 20° to 30° F. for a like period at the Ohio Station. The Pennsylvania Station also showed that alfalfa-molasses silage was superior to artificially dehydrated alfalfa hay in carotene content, the dehydrating process reducing the carotene by about 30 percent.

The occurrence of a nutritional anemia in cattle in the coastal areas was shown by the Massachusetts Station to be due to feeding forage of very low iron content grown on soils low in this element. The addition of iron compounds to such soil gave large increases in the iron content of grasses grown on it. Liberal application of a complete fertilizer to permanent pasture by the Louisiana Station not only increased pasture yields by 58 percent but also increased the phosphorus content of the herbage by nearly 18 percent.

Minerals in nutrition.—The optimum level of various minerals in the animal diet and the effect of deficiencies or excesses are of vital significance in nutrition.

When animals are confined largely or wholly to a roughage ration phosphorus deficiencies frequently occur, particularly in case the forage is produced on soils low in available phosphorus. The Oregon Station found that with heavy milking cows restricted rather closely to a ration of alfalfa hay, phosphorus deficiency occurred unless the ration contained over 0.2 percent of this element. Such deficiency was readily corrected by the addition of phosphorus-rich concentrates to the ration. The Idaho Station showed that rations containing only 0.12 percent of phosphorus resulted in acute aphosphorosis in fattening steers. Such steers required 25 percent more feed per pound of gain than those on an adequate phosphorus diet. At least 2 grams of phosphorus daily per 100 pounds of live weight was required for normal growth and fattening. Calves and lambs required about 2.2 and 2.5 grams of phosphorus daily per 100 pounds of live weight, respectively, for normal growth. Occasional cases of phosphorus deficiency in cattle investigated by the Pennsylvania Station were found to be primarily a result of improper feeding practice and only in minor degree a consequence of low phosphorus content in the soil.

The toxic effect of a high fluorine intake has long been recognized. The Wisconsin Station found that only a small amount of fluorine is transferred through the placenta of the cow to the developing fetus and that so long as milk is the main source of food the bones of calves contain a low and rather constant quantity of this element.

A study of the calcium and phosphorus balance of laying hens on a good ration by the South Carolina Station indicated that during the early laying period pullets were generally in negative calcium balance but later they normally reached a positive balance without any change in the level of egg production. Great individual variation in the ability of hens to utilize calcium was observed, and continued inability to reach a positive calcium balance resulted in cessation of laying. No lack of phosphorus for egg production was observed. One percent of calcium carbonate in the laying ration with no supplemental source of calcium was found by the Rhode Island Station to result in a low production of eggs having low breaking strength of shells and poor hatchability. Better results were obtained by adding a small amount of calcium carbonate to the mash and allowing hens free access to ground oystershell than by supplying 5 or 8 percent of calcium carbonate in the mash without oystershell. The Nebraska Station demonstrated that when supplied at suitable levels in the diet, calcium carbonate and calcium sulphate were equally effective sources of calcium for young growing chicks.

Recent announcements by the New York (Cornell) Station that a small amount of manganese in the chick diet would alleviate the slipped tendon disease and by the Kentucky Station that manganese deficiency in the diet of parent hens was the cause of a certain type of chick embryo deformity has stimulated a great amount of research on the role of manganese in poultry nutrition. The essentiality of this element in preventing perosis (slipped tendon disease) in chicks

now seems well established. The Texas, Michigan, and Kentucky Stations agreed in the findings that approximately from 35 to 40 parts per million of manganese in the diet is the minimum protective level. Higher concentrations were without further value unless the mineral content of the ration was abnormally high. Feeding approximately 20 times this level by the Kentucky Station did not prove toxic. The New York (Cornell) Station also found that manganese is a necessary constituent of bones in the chick and that it is essential for normal bone development in addition to preventing other deformities resulting from and coincident with perosis. Findings at the Wisconsin Station indicated that another unidentified nutritive factor contained in rice bran is essential in addition to manganese in preventing chick perosis.

The vitamin requirements of cattle.—The necessity of adequate amounts of vitamins A and D in the rations of growing and lactating cattle has been frequently demonstrated. Further studies at the Michigan Station have shown that night blindness, papillary edema, and contraction of the optic nerves were associated with a deficiency of carotene in the ration, while other external symptoms of avitaminosis A described by the Texas Station include roughness of coat, nervousness and excitability, depraved appetite, drawn appearance, loss of weight, swelling of the joints, and difficulty of locomotion. The ability of animals to store a considerable reserve of vitamin A in their bodies was shown by work of the Oregon Station in which heifers were maintained on a low vitamin A ration for 6 months, following a pasture period, without serious physiological disturbance.

The Pennsylvania Station has established the minimum level of vitamin D intake which will support normal growth and bone development in calves from birth to 7 months of age to be approximately 300 U.S.P. units per day per 100 pounds of live weight. Cod-liver-oil concentrate and irradiated dry yeast were found to be equally effective sources of vitamin D in these studies.

Mature milking cows have a definite requirement for vitamin D as shown by the South Dakota Station. Cows maintained on a low-vitamin D basal diet with dried beet pulp as a sole roughage suffered a marked decrease in calcium and phosphorus content of the blood, rigidity of the spine, a bending and swelling of the leg joints, and eventually succumbed unless vitamin D was supplied in the ration. This station showed, however, that dairy animals could be carried through the growth, gestation, and lactation stages in the complete absence of sunlight when a liberal allowance of alfalfa hay was provided in the diet.

Deleterious effects of cod-liver oil.—Following a previous announcement by the New York (Cornell) Station that cod-liver-oil feeding resulted in muscular and heart injuries in certain species of herbivorous animals, tests have been conducted to determine the cod-liver-oil tolerance of calves. Daily doses ranging up to 0.7 gram per kilogram of live weight failed to produce any marked muscular injury, indicating that sufficient cod-liver oil to supply optimum levels of vitamin D may be fed safely to calves. Severe injuries were caused in sheep and goats by low levels of cod-liver oil while rats showed a relatively high tolerance, indicating the marked difference in toler-

ance between herbivorous and omnivorous species. Hydrogenation of the oil removed the toxic principle as shown in tests with guinea pigs.

It has been observed that the feeding of certain fish oils, particularly cod-liver oil, to milking cows resulted in a marked lowering of the fat content of the milk. Trials at the New York (Cornell) Station comparing the effect of normal and hydrogenated cod-liver oil and at the Missouri Station comparing normal and hydrogenated herring oil showed that the fat-suppressing factor was removed by hydrogenation since this product had little or no effect on the percentage of butterfat in milk .

Vitamin requirements of swine.—The California Station determined that hogs require from 5.8 to 7.5 micrograms of vitamin A or 25 to 39 micrograms of carotene daily per kilogram of live weight for normal growth and development.

This station also showed that hogs have a definite requirement for various members of the vitamin B complex. A pellagralike condition, that developed in hogs confined to a synthetic basal diet, was alleviated by adding nicotinic acid (the human pellagra-preventive factor) to the diet in the presence of vitamin B_1 and riboflavin. Diets deficient in one or more components of the vitamin B complex also caused lack of appetite, impaired locomotion, and lowering of body temperature and rate of breathing.

Vitamin requirements and sources for poultry.—The vitamin requirements of poultry have been extensively studied in recent years with particular reference to the amounts of vitamins A and D required for normal growth, maintenance, and egg production. Within the past year particular attention has been paid to the essentiality of riboflavin (vitamin G) in poultry nutrition. The Ohio Station has shown that practical rations deficient in riboflavin result in poor growth, decreased egg production, increased mortality, and low hatchability of eggs. The quantitative requirements of growing chicks for vitamin G were found by the New York (Cornell) Station to vary with age, ranging from 350 Cornell units per 100 grams of ration at 2 weeks of age to 100 units at 8 weeks of age. This station also found that the requirements of laying hens to produce eggs of optimum hatchability were approximately 245 units of vitamin G per 100 grams of ration. Young growing turkey poults required about the same amount of vitamin G per unit of weight as chicks according to findings at the California Station. Milk, high-quality legume meals, and green grass are important sources of this factor.

The Wisconsin Station in studying other nutritive requirements of chicks showed that they have a definite and rather constant requirement for the antineuritic vitamin, B_1, amounting to from 20 to 25 International Units per 100 grams of ration. They further found that pure nicotinic acid, which has recently been identified as the pellagra-preventive factor for humans and the antiblacktongue factor for dogs, was ineffective in alleviating chick dermatitis. The factor which prevents this chick disorder is present in liver and is distinct from other known essential dietary factors. The quantitative requirements of growing chicks for this "filtrate factor" (chick antidermatosis factor) is about 100 "chick units" per 100 grams of feed, as determined by the California Station.

With reference to the new sources of vitamins for poultry, the Florida Station found shark-liver oil to be from two to three times as potent in vitamin A as standard cod-liver oil for growing and laying pullets. The North Carolina Station found menhaden-fish oil to be a satisfactory source of vitamin D for growing chicks although somewhat less potent in this factor than good cod-liver oil.

Factors affecting the digestion and utilization of feeds.—The digestibility of carotene in the ration is affected by the kind of animal, the level of carotene supplied, and the source of supply, according to findings at the Texas Station. Chickens digested it more efficiently than rats at similar levels of intake. Low levels were digested more efficiently than high levels, and purified carotene dissolved in oil was more digestible than a similar level provided in alfalfa.

In studying the effects of mechanical processing of feeds, the Ohio Station found that steers masticated chopped alfalfa hay more rapidly and with less chewing than long hay, and that ground hay required less time and energy for both mastication and rumination than long hay. Grinding shelled corn increased the work required for mastication over unground corn. Results obtained at the South Dakota Station showed that dairy cows receiving a ration of alfalfa hay and corn digested finely ground corn more efficiently than whole corn. Crude fiber was the only constituent not rendered more digestible by grinding, and the percentage increase in digestibility of other constituents due to grinding ranged from 5 percent for crude protein to 10 percent for crude fat.

Expressing the composition of feeds in terms of crude protein, crude fat, crude fiber, nitrogen-free extract, and ash has been generally practiced for years. Experiments conducted at the New York (Cornell) Station showed that partitioning the carbohydrates of feeds into lignin, cellulose, and other carbohydrates gave values of greater biological significance and hence of greater worth in predicting feed values.

BEEF CATTLE

Use of grazing crops in beef production.—A conclusion reached by the Louisiana Station that, regardless of the feeding method employed in finishing cattle, the use of improved pasture is the most important single item in profitable beef production in that State appears to represent a dominant trend in the beef cattle feeding program of today. They showed that when there is an abundance of cheap pasture and grain prices are relatively high, and when the market will not pay a premium of at least from 25 to 50 cents per hundredweight for grain-fed cattle, greater profits result from finishing cattle on grass alone.

The Texas Station in cooperation with the Department of Agriculture (B.A.I.) determined that by grazing yearling steers on Sudan grass pasture throughout the summer season the grain required for finishing was reduced approximately 50 percent under that required by the usual dry-lot feeding practice. Feeding a liberal amount of cottonseed cake to steers on the Sudan grass reduced the time required for finishing in dry lot but slightly increased feed cost per hundredweight of gain. The most satisfactory plan of utilizing bluestem grass in fattening steer calves, as determined by the

Kansas Station, consisted in wintering calves well, grazing them for 90 days, and then full-feeding in dry lot for about 100 days. The Nebraska Station found that by grazing yearling steers on alfalfa or native grass pasture for a period up to 140 days preceding the final fattening period material savings in both concentrates and cured roughages were effected, while on the basis of rapidity of gains and market desirability the grazed cattle compared favorably with those fed in dry lot for the entire finishing period.

Roughages for beef cattle.—Ways of profitably utilizing sugar-beet tops for cattle were investigated by the Colorado and Wyoming Stations. The former found that clean tops were of greatest value as silage, whereas dirty tops gave best results when dried, and either method was preferable to stacking the tops which resulted in excessive loss. The latter station showed that under favorable conditions pasturing the green tops offered opportunity for securing higher net returns than feeding dried tops. Supplementary feeding while pasturing the tops increased the rate of gain but did not give economical returns.

A comparison of sorghum silage, peanut hay, and cottonseed hulls as roughages for fattening steers by the Florida Station indicated that when supplemented with a simple mixture of corn, velvetbeans, and cottonseed meal, these widely differing types of roughages produced satisfactory and very similar average daily gains per steer.

The comparative value of corn silage, whole corn fodder, and cut or ground fodder for steers was determined by the Iowa and Michigan Stations. Silage produced more rapid gains and greater total gains per acre of feed. Grinding fodder proved the least economical method of preparation in each case. Silage gave higher net returns over cost of harvesting and storing at Michigan, while under Iowa conditions the cost per unit of live-weight gain was slightly less with whole fodder than with silage.

Molasses in the fattening ration.—During recent years when corn was relatively scarce and high priced, molasses has been extensively used in livestock feeding. The Nebraska Station reports that when used to replace one-half or all the corn in the ration of fattening heifers, molasses was about 86 percent as valuable as corn pound for pound. The Oklahoma Station found that a mixture of oats and molasses (1:1) produced practically as rapid gain as corn in the ration of steer calves. However, replacing one-half or three-fourths of the corn with molasses resulted in slower gains and higher feed requirements per unit of gain.

The Hawaii Station found molasses to be a very desirable constituent in steer-fattening rations under island conditions and rendered stockmen less dependent on outside sources for their feed supply. The Colorado Station in comparing the feeding value of cane molasses and low-grade or C beet molasses for fattening cattle found the latter to be about 87.5 percent as valuable while costing only one-third as much as the former.

Protein supplements for beef cattle.—Findings at the Ohio Station indicated that the allowance of about 1.5 pounds of a high-protein supplement mixture per steer daily throughout the feeding period is a safe and satisfactory level of feeding. Higher levels, while slightly increasing the rate, also increased the cost of gain. Feeding

at an increasing or decreasing rate with advance of the feeding period was not as well adapted to commercial practice as feeding at a constant level throughout. Full feeding of cottonseed meal as a supplement to corn silage and alfalfa hay for fattening steers produced more rapid and more economical gains than when mixtures of ground kafir and cottonseed meal were fed at the New Mexico Station. The addition of cottonseed meal to a basal ration of wheat and alfalfa hay did not improve the economy of gains but did prove desirable with a barley-alfalfa hay ration in trials at the Montana Station. Feeding 1.2 pounds of cottonseed cake daily to brood cows on winter range at the Arizona Station resulted in the calves averaging 4 pounds heavier at birth and 9 pounds heavier at weaning time than those from cows receiving no supplement.

Effects of the ration on quality of beef.—The South Carolina Station in cooperation with the Department of Agriculture (B.A.I.) showed that the color, quality, and palatability of meat from steers finished on cottonseed meal and hulls compared favorably with that from steers fed shelled corn and alfalfa hay. The use of the former type of ration is apparently not the cause of the general discrimination against southern beef. Studies by the Louisiana Station, also in cooperation with the Department of Agriculture (B.A.I.) gave evidence that meat from grain-fed cattle was more tender, of slightly finer texture, less intense and more desirable in flavor of the fat, and more desirable in aroma than that from grass-fattened cattle. There was little difference in flavor of the lean meat from the two groups, and the lean from grass-fed cattle was only slightly darker in color than that from the grain-fed lots.

DAIRY CATTLE AND DAIRYING

Metabolism of dairy cattle.—Seasonal variation in the basal metabolism of dairy cows amounted to 50 percent or more, the highest levels occurring during periods of longest sunlight as determined by the New Hampshire Station. A temperature of about 64° F. proved to be the most comfortable for adult cattle, and basal metabolism increased from 2 to 3 percent for each degree drop in temperature below this point. The California Station showed that, with rising temperature, a uniform increase in respiraton rate occurred from 12 per minute at 40° to 124 per minute at 100°. At temperatures above 80° to 85° the animals were no longer able to maintain heat balance, appetites decreased, milk flow declined, and the characteristics of milk were altered. The energy metabolism of fasting lactating cows was found by the Missouri Station to average about 10 percent higher than in fasting dry animals. Cows demonstrated a remarkable persistency in maintaining lactation during fasting. Milk yield decreased about 50 percent during 72 hours' fast while fat production remained at practically a constant level.

Roughage for dairy cattle.—By developing an all-year system of pasture (346 grazing days) for milking cows, the Tennessee Station effected substantial savings in hay and silage and a 47-percent reduction in grain feeding in comparison with a herd grazed only 198 days and full-fed grain and roughage. The former system resulted in 97 percent as much milk and butterfat and 11 percent higher income

over feed costs than the latter. By grazing cows on alfalfa or a mixture of alfalfa and bromegrass the Michigan Station found it was possible to get a very profitable return from such pastures during the summer period when bluegrass pastures were of very limited value.

The Oklahoma Station found that by supplementing prairie hay with sufficient cottonseed meal to make the protein content equal that of alfalfa, the prairie hay was about 90 percent as efficient as the alfalfa for dairy cows. The Wyoming Station showed that dairy calves weaned from the milk at about 3 months of age made approximately normal gains when fed a limited amount of grain and liberal amounts of high-quality alfalfa hay. Calves fed such hay without supplement after 9 months of age continued to make satisfactory gains.

Yeast in calf rations.—The addition of either dried brewers' yeast or cereal yeast feed to a satisfactory type of calf-starter ration resulted in somewhat greater gains and lower total digestible nutrient requirements per pound of gain in tests at the New York (Cornell) Station. These rations fed as meals were more palatable and produced more rapid gains than when fed in pelleted form.

Vitamins in dairy products.—Factors affecting the original vitamin potency of milk and the influence of handling and processing on the vitamin content of milk and its products are of significance to the ultimate consumer. The Kansas Station found that when cows received large quantities of green feed, butter obtained from their milk contained approximately 30 International Units of vitamin A per gram as compared to a value of about 20 per gram in butter from cows at the end of a summer drought period when very little pasture had been available for several months. Butter from cows continuously confined to a ration of prairie hay and grain showed a value of 11.4 International Units per gram. The vitamin A potency of butter as measured by rapid chemical determination of vitamin A and carotene corresponded closely with values obtained by biological assay in trials at the Texas Station. The Pennsylvania Station found that only slight destruction of vitamin A in Cheddar cheese occurred during the ripening process. The Nebraska Station demonstrated that cheeses vary greatly in vitamin A potency. In general, cottage, Neufchatel, and Limburger cheeses had the lowest vitamin A value.

The marked effect of season and of feeds on the vitamin D content of milk was demonstrated by the South Dakota Station. July milk was approximately four times as potent in vitamin D as April or November milk. Milk from cows receiving alfalfa hay was 50 percent higher in vitamin D than that from cows consuming a like amount of prairie hay, and milk from cows receiving beet pulp as a sole roughage was practically devoid of this factor.

Off-flavors in milk.—The prevalence of undesirable flavors in milk is indicated by a report by the Oklahoma Station that in a large number of observations only 8.3 percent of all samples tested were free from some off-flavors in spite of the fact that careful precautions were taken to avoid feed flavor. Pronounced variation in the flavor of milk from individual cows was evident, particularly with reference to rancid flavor. Rancid samples in general were higher in acidity, in total solids, fat, protein, and salt content and lower in

lactose content than normal samples, and these tendencies appeared to be characteristic of all milk produced by those animals whose milk was frequently rancid. The New Jersey Station demonstrated a close interrelationship in milk between its color (primarily due to carotene), ascorbic acid (vitamin C) content, and flavor, indicating that high carotene and high ascorbic acid contents are coincidental to and help to preserve good flavor in milk.

Oxidized flavor in milk, a prevalent flavor defect which is accelerated by ordinary pasteurizing methods, exposure to sunlight, and aeration, was shown by the Pennsylvania and Michigan Stations to be greatly inhibited or prevented by homogenization at pressures of from 2,000 to 3,000 pounds per square inch.

Variation in the composition of milk.—Both the New Hampshire and Missouri Stations have observed marked seasonal variation in the ratio of fat to nonfatty solids in milk. The tendency for a low solids-not-fat content to occur in summer milk frequently resulted in such milk falling below the legal standards for total solids although the butterfat content was adequate, suggesting the need for revision of legal sandards for milk in certain areas.

Butter production.—Factors affecting churning losses, flavor development in butter, and quality deterioration during storage have been investigated. The Iowa Station, for example, has made extensive studies of factors affecting the production of diacetyl, the principal flavor-producing constituent in butter. By use of a butter starter prepared with a pure culture of citric acid fermenting bacteria and properly adjusting the acidity of cream, a highly flavored butter of moderate acidity and excellent keeping quality was produced. Churning losses of butterfat were found to increase rapidly with increasing acidity of cream up to a certain point, indicating the economic necessity of neutralizing or otherwise controlling acidity in cream. The beneficial effect of oat flour in retarding the development of oxidized flavor in butter, either by direct addition to the cream or by wrapping butter in parchment treated with oat flour, was reaffirmed by the Illinois Station.

On the basis of the initial quality score and ability to hold score during storage, the Illinois Station found that sweet-cream butter ranked first, followed in order by butter from starter-ripened and neutralized cream, and butter from spontaneously soured cream neutralized to the same acidity. Neither initial score, the physical and chemical constants of butterfat, nor rate of oxidation in butter were of much value in predicting the keeping properties of butter. Findings of the South Dakota Station indicated that fresh salted butter had a much lower bacterial count than corresponding unsalted butter and, further, that unsalted butter when removed from frozen storage and held at room temperature increased in bacterial count and deteriorated in flavor more rapidly than fresh unsalted butter or salted storage butter. The Missouri Station showed that butter flavors were partially submerged at serving temperatures of from 40° to 50° F., while full pronounced flavors were manifested at from 60° to 70° F.

Ice-cream production.—The Massachusetts and Illinois Stations agreed in their finding that the addition of 0.5 percent of oat flour to ice-cream mixes markedly retarded the development of oxidized

flavors in the frozen product during holding periods. The Iowa Station showed that the use in ice-cream mixes of condensed whole or skim milk prepared in copper evaporating pans induced oxidized flavors in ice cream much more readily than the use of similar products prepared in stainless steel pans. Frozen condensed skim milk can be satisfactorily used in the preparation of ice-cream mixes, according to the Nebraska Station, thus providing a good means of preserving summer surpluses of milk for fall and winter ice-cream production.

The Michigan, Massachusetts, Wisconsin, and Illinois Stations have each shown that when used in proper concentration sodium alginate possesses practically all the desirable characteristics of gelatin as an ice-cream stabilizer and that its use eliminates the necessity of aging mixes in order to obtain a desired viscosity before freezing.

Cheese production.—A study by the Wisconsin Station indicated that starters used in the manufacture of brick cheese are frequently of low quality, containing large numbers of yeast, gas-producing bacteria, and other undesirable types of organisms which in turn are responsible for much of the low-quality brick cheese produced. This station found that extraneous matter or sediment was not a fundamental cause of poor quality in cheese. The rate and intensity of ripening of Cheddar cheese is materially affected by the curing temperature, initial acidity, and the amount of rennet or pepsin used as a coagulant, while moisture content within a normal range is of small consequence in this respect, according to findings at the Pennsylvania Station. A simple and improved method of determining the moisture content of cheese, in which a small weighed amount of olive oil or cottonseed oil is added to the cheese in the moisture cup before heating over the open flame, has been developed by the Michigan Station.

The method of processing cheese milk has a marked influence on the rate of ripening of blue (Roquefort-type) cheese, according to the Iowa Station. Cheese from homogenized raw milk ripened to a desirable flavor in about one-half the time required for that of cheese from homogenized pasteurized milk. Salting the curd also hastened the rate and intensity of mold growth essential to proper ripening.

Sanitary control of dairy products.—The phosphatase test, which has proved to be an accurate method for determining the efficiency of pasteurization of milk, was shown to be applicable, with certain limitations, for determining the efficiency of pasteurization of ice-cream mixes (Illinois Station) and cream for butter making (Indiana Station). The resazurin test, widely heralded as a rapid test by which milk could be classified as to sanitary quality, has been shown by the Vermont Station to have definite limitations. It proved sensitive not only to the presence and activity of bacteria but also to the presence of cells in milk. It was also very sensitive to strong sunlight or artificial light. Special attention was needed to determine the point in the range of color changes which separated samples needing and not needing further inspection. A report of the New York State Station based on original research of that station and also a compilation of results from other laboratories gave definite evidence that the use of improved media and an incubation temperature

of 32° C. gave a greater spread between the bacterial counts of truly good-quality and truly poor-quality milks than was obtained by the present standard nutrient-agar method, suggesting the need for revision of the present accepted method of determining the bacterial content of milk. Such modifications in technique also gave consistently higher bacterial counts in ice cream than the standard method, as shown by the Kansas and New York State Stations.

Numerous contributions on improved methods and technique for determining the extent and kind of bacterial flora in dairy products include a method of counting viable bacteria in milk by means of the microscope by the New York (Cornell) Station, the classification of hemolytic organisms in milk by the New Hampshire Station, classification of organisms important in dairy products by the Iowa Station, and methods of sampling ice-cream containers for bacterial contamination by the Maryland Station.

SWINE

Forage for swine.—The ability of swine to profitably utilize forage crops during the growing and fattening periods has been further demonstrated.

The Pennsylvania Station showed that pigs full-fed grain while grazing on rape, sweetclover, or alfalfa pastures made from 25 to 30 percent more rapid gains and required from 20 to 25 percent less grain per pound of gain than pigs full-fed grain without forage, while pigs fed limited amounts of grain on such forage showed corresponding savings of grain per unit of gain although gains were made at a slower rate. Tests of the relative merits of several pasture forages for young pigs at the Kentucky Station indicated that, for early summer use, alfalfa was superior to oats and rape, while bluegrass was a poor third. For late-summer pasture, fresh alfalfa was superior to Korean lespedeza, the latter crop proving very unpalatable as it reached maturity.

The Indiana Station found that pigs confined on floors for 1 month after farrowing became anemic and suffered a high mortality, while pigs removed to sod within 1 week after farrowing maintained a normal hemoglobin level of the blood, suffered lower mortality, and were substantially heavier at weaning time.

The California Station studied the effect of alfalfa pasture on the hardness of pork fat and found that the carcasses of pigs which had received alfalfa pasture were as hard as those fed the same concentrate rations in dry lot.

Grains for swine.—Barley as a sole ration for swine exhibited a number of nutritive deficiencies as shown by the California Station. A combination of barley and protein concentrate fed in dry lot produced more rapid gains than barley and green pasture, indicating that the nutritive factors in pasture do not adequately supplement barley. The Nevada Station obtained excellent gains in swine with a ration of barley, alfalfa meal, and skim milk, and additions of cottonseed meal, linseed meal, or tankage did not enhance the value of such a ration.

Trials at the South Dakota Station indicated that finely ground proso millet seed was 93 percent as efficient as corn in a well-balanced ration for fattening pigs, while ground barley was intermediate in

value. Hominy feed and corn had practically equal fattening value for hogs but the former produced a high percentage of soft-fat carcasses, according to findings of the Indiana Station. The Louisiana Station reported that slightly damaged rough rice was approximately 90 percent as valuable as corn when replacing it in the swine-fattening ration, and that rice screenings could be successfully used to replace one-half of the corn in the ordinary ration. Blackstrap molasses when used to replace one-half or all of the corn in a corn-shorts-mineral ration was found by the Oklahoma Station to be 84 percent as valuable as the corn pound for pound.

Protein supplement for swine.—When fed free-choice in the ration of fattening hogs the South Carolina Station found animal proteins to rank in the following order of efficiency: Menhaden-fish meal, sardine meal, tankage, and meat-and-bone scraps. The North Carolina Station compared a wide variety of protein supplements and concluded that mixtures of menhaden-fish meal and cottonseed meal or soybean meal (1:1) or a combination of the three (1:1:1) were the most satisfactory supplements to corn and minerals for fattening pigs in dry lot. The Wisconsin Station found that vegetable protein concentrates alone (i. e., soybean meal or a mixture of linseed meal and wheat middlings) as a supplement to corn and alfalfa meal produced satisfactory gains in hogs when suitable quantities of ground limestone or bonemeal were added to the ration. One and one-half percent of bonemeal gave best results. When only limestone was used about 1½ percent proved superior to large amounts of this mineral since it appeared desirable that the calcium: phosphorus ratio should not exceed 2:1. The Ohio Station found that in economy of gains of pigs on pasture supplements of fish meal, soybean-oil meal, iron-treated cottonseed meal, linseed meal, and meat-and-bone scraps ranked in the order given.

Curing pork.—The Alabama Station demonstrated that, by boning the warm pork carcass, dry salting, and packing in ice for 24 hours, and then draining and resalting, pork could be cured for home consumption during any month of the year under southern conditions. The Pennsylvania Station studied the rate of salt penetration in pork and showed that 7 days per inch of thickness was the minimum time during which hams and bacon should remain in dry cure, while hams required from 9 to 11 days per inch of thickness to cure in sweet-pickle solution. Temperature did not affect the rate of salt penetration in dry cure but in sweet-pickle penetration was more rapid at higher temperatures.

SHEEP

Regional adaptation.—The Colorado Station, through long-time experiments, has demonstrated that under dry-land farming practices in the Plains area, sheep may be used advantageously for grazing on fallowed areas and green-manure crops and that in combination with permanent native sod such crops provide up to 195 days' annual grazing.

Rations for fattening lambs.—The New York (Cornell) Station found that a low-protein ration of corn and grass hay gave unsatisfactory results with lambs, whereas corn and alfalfa made a very satisfactory lamb-fattening ration which was but slightly improved

by additions of either a protein supplement or bonemeal. Corn silage proved entirely satisfactory as a sole roughage for lambs when fed in combination with corn, protein supplement, and a calcium supplement. However, it was of greater value when alfalfa hay was also fed. Lambs constantly confined in the feeding barn made more economical gains than lambs fed a similar ration but allowed outdoor exercise. The Colorado Station reported that the addition of cottonseed meal to a basal corn-alfalfa-hay ration promoted greater and more economical gains in lambs. Discard beet molasses was profitably utilized as a partial substitute for corn in such rations.

Cottonseed meal fed in excess of the lamb's protein requirement, at the Oklahoma Station, had a feeding value of 85 percent of that of shelled corn pound for pound. The creep feeding of lambs running with their mothers on abundant wheat pasture proved profitable. The Montana Station found that self-feeding a ration of oats, dried beet pulp, and ground alfalfa in the proportion of 1:2:1 gave more efficient gains and more profitable returns than other rations in which long alfalfa hay or long native hay were fed with oats and beet pulp.

Rice polish or mixtures of rice polish and rice bran were only slightly inferior to corn for fattening lambs, while rough rice proved definitely lower in feeding value than corn in trials at the Louisiana Station. The Georgia Station reported that ground *Lespedeza sericea* hay, although readily consumed by lambs, was worth only 81 percent as much as ground cowpea hay in lamb-fattening rations.

Effects of shearing.—A comparison of the fattening qualities and market value of shorn versus unshorn Merino lambs by the Pennsylvania Station indicated that under average weather conditions and average prices the shorn lambs would give a higher net return than the unshorn ones. Trials at the Indiana Station indicated that native feeder lambs sheared in the summer maintained better appetites, made slightly greater daily gains, and yielded about 21 percent more profit per lamb than unshorn ones. It was necessary to protect shorn lambs against flies for from 2 to 3 weeks after shearing, and the short-staple wool obtained was relatively low in value. The Texas Station found that shearing sheep twice a year resulted in a slightly greater annual yield of wool per sheep than for those sheared once a year but that wide and rapid fluctuations in market prices may offset any net gain in fleece weight so that shearing twice a year might result in financial loss. The frequency of shearing had little influence on the percentage of lambs dropped. Physiological studies at the New Hampshire Station showed that at moderate atmospheric temperatures shearing sheep resulted in about a 10-percent increase in basal heat production over unshorn ones, while at lower temperatures the increase in metabolic rate due to shearing was much greater.

POULTRY

Range for chickens.—In trials at the Arizona Station there was little difference in the growth rate and mortality of chicks reared to 18 weeks of age on concrete floors, wire floors, or green-barley range. The New Mexico Station found that providing laying hens with green range throughout the year materially reduced the cost of egg production, but range was not indispensable since hens confined in pens and fed cod-liver oil, dried buttermilk, and alfalfa-leaf meal

produced practically as well and suffered only slightly higher mortality than hens on range. Alfalfa range throughout the year proved superior to a combination of wheat range in winter and Sudan grass range in summer or to supplying fresh-cut alfalfa to the flock.

Proteins for poultry.—The Nebraska Station, through a series of controlled feed intake and body analysis experiments with young chicks determined that the nitrogen, calcium, and phosphorus retention by chicks was greater when a multiple source of animal protein was fed than when a single source was employed. Replacing one-third of the mixed animal-protein supplement with soybean meal did not reduce the nitrogen retention but similarly substituting cottonseed meal or linseed meal resulted in lower nitrogen storage. Using a basal chick-starting ration containing meat scrap, dried buttermilk, and alfalfa meal as principal sources of protein, the South Carolina Station found that replacing up to three-fourths of the meat scrap with cottonseed meal did not affect the growth rate of chicks.

The Alabama Station demonstrated that ground peanuts and peanut meal, while unsatisfactory as a sole source of protein for chickens, could be satisfactorily used in combination with animal proteins. Dried buttermilk proved superior to meat scrap as a supplement for peanut feeds. Increasing the protein content from 14 to 18 percent in the diet of White Leghorn pullets served to materially reduce mortality in trials at the West Virginia Station. Also, higher egg production and lower feed requirement per dozen eggs resulted when a 30-percent protein diet was fed than when a 24-percent protein diet was used. Whole dried egg as a source of protein for poultry resulted in a relatively very high nitrogen retention. The possibility of using ground lespedeza seed and screenings in poultry feeding was demonstrated by the Kentucky Station where up to three-fourths of the meat scrap in a standard poultry ration was successfully replaced by this product. With the increase of lespedeza production the use of this product may become a matter of considerable importance.

The Indiana and Delaware Stations agreed in showing that the rate of growth of broilers increased with increasing amounts of proteins in the ration up to about a 20-percent protein level. Relatively high protein levels were considered advantageous since a given weight could be obtained in a shorter time with little difference in feed cost per unit of gain. The latter station also found that feeding a dry fattening mash in place of the regular broiler mash during the last 8 days of the feeding period decreased gains and failed to improve the pigmentation or fleshing of the birds.

Grains for poultry.—Lightweight lower grades of corn, wheat, and barley proved at the South Dakota Station to be equally as good as higher grades of these cereals in starting, growing, and laying rations. It was also shown that red or white proso millet seed could successfully replace a high percentage of other cereals in poultry rations. The Arizona Station concluded that locally grown red milo grain or barley could successfully replace corn in poultry rations when proper vitamin supplements were added. Tests at the Louisiana Station gave evidence that not over 7.5 percent of molasses should be used in an all-mash laying ration and that not more than from 5 to 7 percent should be included in the chick ration. Rations con-

taining from 10 to 15 percent of molasses gave good results during short fattening periods.

Detecting infertile eggs.—By use of a candling machine developed by the Alabama Station infertile eggs can be detected after only 15 hours' incubation and before any appreciable deterioration in their food value has occurred.

Egg quality.—The Washington Station noted a distinct seasonal effect on the albumin quality in eggs. A downward trend was observed from October to July, after which the quality tended to improve. No significant differences were found by the Pennsylvania Station in the mineral content or in the nutritive value of firm and watery egg albumin. The Iowa Station demonstrated that the inclusion of 1⅓ percent of irradiated yeast in the mash ration fed to laying hens was effective in increasing the vitamin D content of eggs, resulting in a rather constant concentration of about 400 units of vitamin D per egg produced. The Kentucky Station found that supplying liberal amounts of vitamin D to laying hens either by administering cod-liver oil or allowing hens access to sunlight increased the amount of calcium and phosphorus in egg yolks.

The rapid deterioration in quality of dirty eggs held in cold storage has long been a serious economic problem. The Missouri Station found that by washing dirty eggs in a dilute solution of sodium hydroxide (lye) before placing in cold storage the cleaned eggs kept equally well for from 8 to 10 months, commanded as good prices on the market, and possessed edible qualities fully equal to originally clean eggs stored under like conditions.

Turkey production.—A comparison of confinement versus open range for turkey breeding stock at the New Hampshire Station gave evidence that the confinement method offers certain commercial advantages. No significant differences in maintenance of body weight, egg size, or hatchability of eggs were apparent, and the slightly greater feed cost for confined birds was more than offset by their materially greater egg production.

The Washington Station found that young turkeys fed a mash ration in pelleted form along with scratch grain required somewhat less feed per unit of gain and gave a higher net return over feed cost at 28 weeks of age than those fed the same mash as a meal.

The effect of fish meals and fish oils in the turkey ration on the flavor of the meat has been investigated by a number of stations. The Michigan, California, Pennsylvania, and Virginia Stations all found that feeding these products up to the time of slaughter generally resulted in fishy flavor and odor in the carcass. Removing these products from the diet 8 weeks before the end of the feeding period tended to eliminate the occurrence of these off-flavors and odors. Drawing the fowls immediately after slaughter and holding at low temperatures reduced or eliminated such undesirable off-flavors.

BEES

Effect of diet on weight of adult worker bees.—The Wisconsin Station found a substantial decrease both in weight and in nitrogen content of all parts of the bodies of experimental bees fed a pure carbohydrate diet for a period of 189 days. The greatest change took

place in the abdomen of the bees. A final decrease in the percentage of dry matter and of nitrogen in the fresh and dry weights of the bees occurred. There were exceptions to this general decrease in that the dry matter of the heads and intestines increased slightly while there was a considerable increase in the percentage of nitrogen in the dry matter of abdomens. The greatest variations were in the percentage of nitrogen of dry weight and of nitrogen in the abdomens. The smallest variations were in the thoraxes of the experimental bees.

Influence of size of brood cell on size of honeybee.—Significantly larger worker bees were obtained through the use of an enlarged cell foundation in investigations of the Iowa Station. The average percentage increases of the linear measurements of the bees were almost proportional to the percentage increases of the diameters of the brood cells. The increase in the size of the bees did not quite keep pace with increases in cell size. The size of the brood cell apparently did not affect the variability of the adult worker bee, except possibly in dry weight.

GENETICS

Annually the research practices of the stations make definite progress in the determination of factors responsible for the inheritance of characters of economic importance in livestock. Progress was made during the year in studies of the mode of inheritance of these characters, determination of the location on the chromosomes of the factors, and findings which would lead toward the development of improved families and strains carrying desirable complexes of these qualities.

Sex ratio of mules.—Because of the suggested differences in the mortality of the sexes in hybrids, special interest is attached to the sex ratio of horse and mule foals. The Wisconsin and Oklahoma Stations determined that there were 52 percent of males among horse foals studied. Among mule foals the percentage of males was only 44.28 percent. Data point toward higher percentages of males than of females in most mammalian embryos at the earliest ages. There is a much greater fetal mortality in males than in females, which is evidently greater in the hybrid (mule) than in horses.

Color inheritance in cattle.—Using cattle differing in genotype and coat color, an intensive study was made at the Kansas Station of the type and amount of pigment in the hair. It was found that black pigment was always present, even in white hairs, in the form of granules or clumps, but it varied in concentration and location. Red pigment was of different shades and was nongranular. It was completely diffused in the hair, although it sometimes appeared granular in the skin. The shade of red hair was determined by the shade of red pigment and the amount of black pigment present. Only a few hairs, and those of albinos, were devoid of any pigment. It is of interest that four types of white hair, differing genetically, were observed, i. e., white spotting on Ayrshires, Hereford spotting, dominant white as found in Shorthorns, and albino.

Inbreeding dairy cattle.—The results of 6 years' investigations dealing with the possibilities of improving the transmission of high milk and fat production through inbreeding at the New Jersey Station showed that certain inbred sires were especially influential in increasing the production of milk and butterfat. The inbred daughters of one sire produced an average of nearly 3,000 pounds more of milk

and 175 pounds more of fat than their dams. Results of the inbreeding experiment have shown that inbreeding may be employed as a tool toward maintaining an increased butterfat content of Holstein milk without reducing production. Other findings were that inbreeding may increase or decrease size and vigor in certain families, but the disadvantages may be guarded against and improvement made in the desired characteristic by selection.

Inheritance of milk production.—Inasmuch as there is continued controversy as to the best methods of determining the transmitting quality of dams or sires regarding milk and butterfat production, studies have been continued on the correlation of the production of dams and their daughters. The Florida Station found a small but positive tendency for daughters of higher-producing dams to yield more milk than did those from medium- and low-producing dams. Likewise, the same station found differences in the transmitting ability of sires, but no sires produced daughters whose records were all above their dams. The tendency was for daughters of the higher-producing dams to produce smaller amounts of milk and fat than their dams.

The Minnesota Station in an analysis of records from the experiment station herd found that initial maximum yield and persistency of production were inherited independently.

Hereditary effects on weaning weights of pigs.—From a statistical analysis of the variance in the 60-day weaning weights of over 1,600 Poland China pigs produced in an inbreeding experiment at the Iowa Station it was estimated that about 18 percent of the variance was due to heredity, whereas 40 percent was accounted for by environment common to litter mates and 42 percent by environment not common to litter mates. Sex and size of litter were only minor factors in causing variability in weaning weight.

Cross-breeding poultry.—The Oklahoma Station found that crossing breeds had no influence on mortality in the laying flock or growth rate unless rapid growth rate was expressed in at least one of the parental stocks. Crossing breeds did not seem advisable for most poultry enterprises. In the production of broiler chickens, 50 percent of the differences in the feathering at broiler age was found due to heredity and 50 percent to environmental conditions. The station found that Rhode Island Red chickens breeding true for the sex-linked gene for early feathering were not subject to the loss caused by the appearance of "bare-backs" in strains lacking the early-feathering gene.

The Arkansas Station produced white cross-bred broilers with a few black feathers by mating Rhode Island Red hens with White Wyandotte roosters. The cross-breds were markedly superior to either parental type and were as large at 10 weeks of age as the Rhode Islands Reds at 11 weeks and the White Wyandottes at 12 weeks. At 12 weeks of age, the average weight of the cross-breds exceeded the average weight of the two parental stocks by 0.6 pound, and only 86 percent as much feed was required to produce 100 pounds of gain in the cross-breds as in the parental stocks. Other breeds were crossed, but none of the cross-breds were superior to both parental types.

The Hawaii Station found hybrids from crossing Japanese Sham and Game males with Barred Plymouth Rock, Rhode Island Red, and White Leghorn hens to be superior to purebreds for the production of market poultry.

Breeding for egg production and egg quality.—A statistical analysis at the California Station on the relation between length of the laying year and age at sexual maturity showed—

that the usage of the length of biological laying year as a criterion of persistency is fallacious, that it has not demonstrated linkage between genes for sexual maturity and persistency, and that no evidence for such linkage is obtained when age at last egg is used to measure persistency.

Three lines of Rhode Island Reds were selected at the Massachusetts Station for small, medium, and large egg size. The results of crossing these strains indicated that the inheritance of egg size depends upon three dominant genes. One gives small egg size, combinations of the other two give large egg size, and all three give eggs that are of medium size. The sandy-shell character and high shell porosity of eggs depend on recessive genes. Shell pigmentation is controlled in inheritance by multiple factors. In general, the results indicated no advantage in selecting for hatching purposes pullet eggs that weighed more than 26 ounces per dozen. Three years' studies at the Pennsylvania Station showed egg shape to be clearly inherited.

Breeding for reduced mortality.—Through selective breeding, mortality in the laying flock was reduced by the Pennsylvania Station from nearly 50 percent to almost nil in certain families at the end of the first laying year. The evidence indicated that fowl paralysis can at least be partly eliminated by the use of females from families that show resistance to the disease and by the use of hen breeders in preference to pullet breeders.

In studies by the Iowa Station it was found that top-crossing inbred sires with other birds of the same species resulted in better fertility, hatchability, and lower mortality to 8 weeks of age than inbreds or noninbreds.

Through selective breeding for low mortality in a high-producing flock, the Massachusetts Station found it possible to develop without culling a strain with mortality of not more than 15 percent during the first laying year.

Strains of White Leghorns were studied at the New York (Cornell) Station which exhibited marked differences in mortality. This was especially true for the progeny of different sires.

The laying-house mortality of the heavier Rhode Island Reds was found by the Massachusetts Station to be lower than for birds losing weight or gaining less than 1.5 pounds from housing at about 6 months of age to March 1. If pullet breeders were to be employed, it was found highly desirable that they have ample body weight at 11 months, when the maximum body weight was usually attained. Birds increasing about 1.5 pounds from housing at about 6 months of age to March 1 laid more eggs of superior size than birds making smaller weight increases.

Inheritance of feather structure and feathering.—The Kansas Station found that in three strains of Rhode Island Reds, differing in rate of feathering, selection within the well-feathering and poor-feathering lines at from 7 to 8 weeks of age was effective in segre-

gating strains differing genetically. In crosses between them, the well-feathering character seemed to be incompletely dominant to poor feathering and was not sex-linked. Early feathering as it occurs in White Leghorns is sex-linked and recessive to late feathering. Although feeding vitamin A and various grains had little if any significant effect on feathering, feather development was stimulated by thyroxine, high humidity, and low brooding temperatures. Females feathered at an earlier age than males. Another abnormal feather condition characterized by a fraying of the flight and tail feathers was described by the same station. This condition was inherited as a simple recessive factor.

Crossing pheasants and fowl.—The Connecticut (Storrs) Station found that although it has been reported that crosses of pheasant males with the domestic fowl produce an excess of male hybrids, pheasant hens crossed with Creeper and White Leghorn roosters by artificial insemination produced 66 male and 69 female progeny. Although pronounced sex differences in the ratio were not observed, there was heavy mortality during the first week of incubation.

Species-specific characters in pigeons.—In serological studies at the Wisconsin Station it was found that different species of pigeons and doves carried characters in their red blood cells which were in some cases specific for the different species, whereas certain of the characters were common to more than one of the species. The behavior of these cellular substances and the combinations carried by purebreds and crossbreds were found to be definite for each type. It is possible that these cellular characters may serve as valuable tools for ascertaining how such characters as egg size and egg production in chickens are determined.

Chromosome map of the fowl.—One objective in genetic studies points toward the identification of various factors responsible for determining the different characteristics and their location on specific chromosomes. So far, little progress has been made in this direction with animals of economic importance except in case of poultry. Through studies at the Kansas and New York (Cornell) Stations it has been possible to locate genes in at least five chromosome groups with estimates of the relative distances between some of the genes on these chromosomes. This furnishes tangible evidence of progress in the identification and location of genetic factors in the domestic fowl.

Disease resistance.—Studies at the Illinois Station have demonstrated clearly that resistance and susceptibility to pullorum disease in chickens may be increased by selective breeding. It appeared that the lymphocytes are a defense mechanism against the disease. Resistant strains showed an appreciably higher count of lymphocytes than susceptible strains.

The California Station reported hereditary differences in the resistance of sheep to stomach worms, suggesting the possibility of developing strains of desirable type and quality resistant to these parasites.

PHYSIOLOGY

Physiological studies have made progress along two rather definite lines, the role of the endocrines both in reproduction and lactation, and the precursors of the constituents of milk. The increased interest in artificial insemination led to concentrated studies of the reproduc-

tive processes. There is much interest in learning how semen samples may be preserved and what is the most opportune time for conception in the female.

Reproduction in sheep and swine.—Because of the growing interest in improving methods of artificial insemination in livestock production, special studies at the Missouri Station were made on boars and rams. It was determined that the normal boar produced from 125 to 500 cubic centimeters of semen per ejaculation, with a sperm concentration of from 25,000 to 1,000,000 per cubic millimeter. Removal of the secondary reproductive organs from 13 boars to determine the role of each indicated that only about 2 to 5 percent by volume of the amount of semen came from the epididymis and testicle, whereas from 55 to 70 percent originated in the prostatic and urethral glands, from 15 to 20 percent in the seminal vesicles, and from 10 to 25 percent in the Cowper's glands. The relatively small portion of the secretions originating in the testes is surprising. Removal of the seminal vesicles and Cowper's glands did not affect mating desire nor reduce fertility in the boars. Variations in sperm production by rams were also investigated. It was found that there was no relation between the number of sperm produced and the mating desire, although seasonal effects and excessive breeding influenced sperm production. Detailed information was obtained on the chemical characteristics of the semen.

Numerous investigations have emphasized the intimate relation between the endocrine secretions of the pituitary and reproduction. Changes in the cellular composition of the pituitary gland of ewes in various stages of reproduction were also studied by the Missouri Station. Nine different cell types were identified, and it was suggested that both granular and nongranular types were instrumental in the production of the follicle-stimulating substances. Granular cells were found to produce a luteinizing and possibly a mammotropic substance required for the growth of the mammary gland during the last half of the gestation period.

It is of interest that of eight ewes at the Idaho Station artificially inseminated with sperm collected from the Department of Agriculture (B.A.I.) Sheep Experiment Station at Dubois, Idaho, two ewes inseminated during the last half of oestrus and one near the end of oestrus produced lambs. The sperm samples in these investigations were shipped from Dubois to Moscow, Idaho, and were used in from 22 to 50.5 hours after collection. Approximately 50 percent of the spermatozoa were motile at the time of insemination.

Artificial insemination with cattle.—The practicability of artificial insemination for breeding dairy cattle was studied at the Minnesota Station. Breeding efficiency could be maintained and oftentimes improved if the sperm samples were introduced into the cervix within 5 hours after collection. Best fertility was obtained when the cows were bred shortly after passing out of heat.

The New Jersey Station investigated methods employed in Denmark in cooperative artificial insemination associations and found that an average of 1.2 services were required per conception. This is contrasted with 1.8 services required under conditions of natural breeding.

Functional activity of the right and left bovine ovaries.—Observations at the Missouri Station on slaughtered female cattle showed

that 73.5 percent had the largest follicles in the right ovaries and in 60 percent the most recent corpora lutea were found in the right ovaries. In 66 percent of the pregnant cows the corpora lutea of pregnancy were found in the right ovary, suggesting that the right ovary is functionally more active than the left ovary in cattle.

Growth and development of the hen's egg.—The growth of the ovum, which eventually becomes the egg yolk, has a direct bearing both on the rate of laying and on yolk size. The Kansas Station determined the rate of growth of the egg yolk by administering fat-soluble dyes to the hen at regular intervals, which were deposited in the yolk in concentric bands. Growth during the interval between administration of the dyes could be ascertained in the hard-boiled eggs. A large percentage of the yolk growth was found to take place in the last 8 to 12 days before laying. The rapid accumulation of the yolk within the follicular membranes before ovulation was not responsible for the rupture of these membranes and the resulting release of the ovum from the ovary.

Physiology of milk secretion.—Much interest has been expressed in experimental work pertaining both to the role of the endocrine secretions in stimulating milk secretions and the part played by different substances in the blood stream as percursors of the components of milk. The New York (Cornell) Station compared the composition of the blood before entering and after leaving the mammary gland. The cell volume, density, total solids, and iron of arterial whole blood were lower than in venous blood. There was no indication that phospholipid fatty acids or cholesterol were removed by the secreting gland, indicating that these are not precursors of milk fat. Total lipids were consistently lower in venous samples, and the values for fatty acids present as neutral fat indicated that the gland must be removing this fraction of the blood lipids as a precursor of milk fat.

Further comparisons of the arterial and mammary venous blood in studies at the Missouri Station indicated that the mammary gland can produce urea from some nitrogenous source which undoubtedly comes indirectly from feed protein. These results suggest reasons for the stimulating effect of high-protein diets on lactation.

By the use of lactating goats, the Missouri Station further found that only 85 percent of the lactose formed in the mammary glands during experimental periods could theoretically be accounted for by the removal from the blood of glucose and lactic acid. The possibility that amino nitrogen in the blood serves as another source of carbohydrates in milk secretion to make up the difference seemed probable. In other studies of the nitrogen metabolism in the mammary gland, negative nitrogen balances in the mammary gland for some time after milking, with a gradual change to a positive balance, indicated that nitrogen may be stored in the gland for future milk production.

Further work conducted at the Missouri Station confirmed more emphatically the role of the pituitary in milk secretion. In addition to prolactin, which directly stimulates the secretion of milk, another hormone designated as mammogen regulated the extent of growth or size of the udder and thus indirectly the ability of the cow to yield large amounts of milk. This hormone stimulated growth of the duct and lobule-alveolar systems of the mammary glands of castrated rab-

bits and rats, but no response was obtained from such animals through the administration of prolactin, the lactogenic hormone which was known earlier. In considering the relationship of the lactogenic hormone to milk production, determinations were made on the presence of the hormone in about 500 cattle pituitaries in comparison with the pituitaries of laboratory animals in different stages of reproduction. These results showed significant differences between beef and dairy cows. Fresh anterior lobe tissue from dry and open, lactating and open, and lactating and pregnant dairy cows contained about 70 percent more prolactin than the pituitaries from beef cows in the corresponding reproductive status. Dry and pregnant dairy cows showed the presence of 37 percent more prolactin than dry and pregnant beef cows. Following parturition the prolactin content of the pituitary glands of rats and guinea pigs was nearly doubled as compared with normal animals.

Injections of oestrogens into ovariectomized female rats and normal and castrated male rats and guinea pigs at the Missouri Station increased the prolactin content of their pituitaries. It is of interest that the test for the presence of prolactin is made by intradermal injections of suspensions of the dried gland over a limited area of the crop gland of pigeons. Positive tests cause proliferation of the crop gland at the point of injection.

In further studies of factors affecting the hormones of the pituitaries, the Nebraska and Missouri Stations found that the prolactin content per gland was just as great in vitamins A- and E-deficient rats as in normals. However, deficiencies in the B complex and D resulted in reduced amounts of prolactin per gland.

In studies of the influence of thyroxine on milk and butterfat yields, the Missouri Station was able to increase milk yields from 10 to 20 percent by three successive doses of from 10 to 20 milligrams of thyroxine. Fat percentage was also markedly increased and solids-not-fat slightly increased. Large doses of whole anterior pituitary gland extracts were required to bring about increased milk yields in dairy cattle.

Theoretical study of relations of endocrines to reproduction.—Many experiments are being conducted with laboratory animals to discover the role of the endocrines, particularly those secretions of the pituitary, in the reproductive cycle, involving ovulation, implantation of the ovum, normal pregnancy, and the subsequent lactation. For example, the California Station found some evidence that litter size in rats could be increased by the administration of gonadotropic hormones from pregnant mare serum.

Preliminary studies of the effects of the hormones on lactation have been conducted at the California Station with rats, rabbits, and guinea pigs, and methods have been developed for assaying the hormones with these animals and with pigeons.

DISEASES AND DISORDERS

The search for means of protecting livestock from conditions that contribute to their death or to the loss of effective production due to sickness is never-ending. As soon as one problem is brought under control another makes its appearance. The situation is complicated by the fact that infectious diseases are not the only factors entering

the picture. Parasites, faulty nutrition, and poisonous plants also contribute to the complicated conditions that keep research workers ever on the alert.

CATTLE

Mastitis of dairy cattle.—The widespread incidence of mastitis among dairy cows led the New York State Station to inquire into the result of the infection on total milk and fat production. No appreciable effect upon the persistency of production was noticeable until the infection had advanced sufficiently to cause the milk to have an abnormal appearance. The disease did not affect milk-fat production independent of total production. Results obtained at the Connecticut (Storrs) Station showed that when only one quarter of the cow's udder was affected the loss in milk yield was negligible. With each additional affected quarter the loss was successively greater. When all four quarters reacted the loss could amount to as much as 15 or 20 percent.

Vaccines prepared by the New York State Station from the causative organisms of mastitis gave no evidence of increasing the resistance of dairy cattle to the disease. Similar vaccines had little or no therapeutic action in the treatment of latent or chronic udder infections. From a practical standpoint the station found it was impossible to maintain a herd free from cows that discharged mastitis streptococci in the milk, but that it was possible to maintain a herd relatively free from cows that produced abnormal milk. In an attempt to eradicate the disease by the use of drugs the Idaho Station administered sulphanilamide orally to infected cows. Immediately after the drug appeared in the milk the streptococci disappeared and the appearence of the milk improved in cases where the udder was swollen and the milk had been abnormal. However, it was significant that within 3 or 4 days after sulphanilamide had disappeared from the milk the streptococci reappeared, indicating that the infection had not been eliminated.

Various tests have been devised for the identification of mastitis. While all the tests developed have considerable merit, each has its limitations, and many studies have been undertaken to discover means to improve them. A study of the mechanism of the reaction of the Hotis test at the Washington Station indicated that this test was not specific for *Streptococcus agalactiae*, the most common causative organism of mastitis. The characteristic reaction of this test was produced by any one of a number of organisms that possessed certain characters. Working along similar lines the Michigan Station found that the results of the Hotis test were not constant on repeated testing of milk from positive or negative cows. Further studies showed that the microscopic examination of properly collected milk samples was an accurate means of diagnosing streptococcic mastitis in dairy cows. On the other hand, large numbers of contaminating bacteria may enter the milk as a result of improper technique and those that reproduce therein may overshadow the microscopic field, obscuring the streptococci that may be present in small numbers. The metabolic products of the contaminating bacteria may also inhibit the growth of the streptococci. The use of proper technique in collecting milk samples is indicated as a result of the research.

Bang's disease (infectious abortion).—Findings obtained at the Arizona Station over a period of years indicated that it was possible and feasible under conditions in that State to eradicate Bang's disease from dairy herds by testing and segregating infected animals on the same farm. It is pointed out that good fences and careful supervision are necessary in carrying out the segregation plan. Reactors should be removed as far as possible from the negative cows.

Studies at the Minnesota Station have shown that it is possible, through careful selection and study, to arrive at a reasonably accurate diagnosis and disposition of particular individuals showing suspicious reactions to Bang's disease. A policy for the disposition of such animals based on a single test has been a subject of considerable controversy. These results show that such a hard and fast rule is impossible. It is necessary to have the results of a series of tests over a considerable period of time, together with information on duration of pregnancy and an adequate herd history in order to make proper deductions regarding the animals. The results showed that in the interim animals having a suspicious titer for the disease were not dangerous and would not spread infection in an otherwise clean herd.

Milk fever.—Studies, conducted over a period of years, at the Kentucky Station showed that some cows became susceptible to milk fever with the second calf and this susceptibility apparently increased up to the fifth or sixth calf. Initial cases, however, continued to appear up to the eleventh calf. Many cows showed a tendency to have more than one case of milk fever, this condition being most marked in the Jerseys observed. In most cases the milk fever cows had an average milk production well above the average of the herd. The variation in the number of cases of milk fever occurring each year was thought to be due at least in part to a lack of rainfall, through its influence on the quality of roughage.

Bovine allergic dermatitis.—Investigations conducted by the Kansas Station revealed that allergic dermatitis, also known as wheat poisoning, blistering disease, itching disease, light sensitization, etc., occurred over the entire State, and had also been reported from surrounding States. The disease made its appearance in March and continued through the first part of June. Mortality was less than 1 percent and the chief loss consisted of a decreased milk flow and loss of flesh. It was believed that some substance eaten by animals while on pasture sensitized the skin, which, in turn, was activated by the sun's rays. Almost without exception the white markings and the nonpigmented hairless areas were affected. Poor winter rations were conducive to bringing about the condition. Calcium gluconate and glucose solutions appeared to be beneficial in the early stages of the disease, while ointments and oils were helpful in restoring the epidermis and hair to affected areas and as fly repellents.

Red water disease of cattle.—The Utah Station discovered that animals suffering with post-parturient hemoglobinuria (red water disease) had a low blood-phosphorus content. The disease is especially common when cows are fed alfalfa and beet pulp and other feeds low in phosphorus. On the other hand, the disease does not develop in herds fed adequate quantities of phosphorus, nor is the blood phosphorus below normal in the latter herds.

Internal parasites of dairy cows.—Liver flukes are very prevalent in most of the dairies of the Territory of Hawaii and cause large economic losses, according to the Hawaii Station. Experiments with the drug Distol, containing aspidinolfilicic acid, hexachloroethane, and talc, have demonstrated it to be highly efficacious in destroying the parasite (*Fasciola gigantica*) without damage to the animal. Of the various snails found in Hawaii only one species (*Fossaria ollula*) has been found to be a carrier.

SHEEP AND GOATS

Pregnancy disease of ewes.—Prompt and repeated injections of glucose were found by the Illinois Station to be effective in protecting ewes against pregnancy disease, or lambing paralysis. The condition is probably caused by improper feeding, but the glucose treatment gave favorable results in the early stages of the disorder when correct feeding methods failed. Rations rich in concentrated carbohydrates fed during the last few weeks of pregnancy and the first 6 to 8 weeks after parturition ameliorate the disorder. Daily additions of corn sugar, blackstrap molasses, or brown sugar at the rate of ¼ to 1 pound per ewe, together with exercise, aided in protecting pregnant animals against the occurrence of the disease.

Abortion in ewes.—The Wyoming Station reported the isolation of an organism from field material which produced abortion experimentally in pregnant ewes. A study of the morphological, cultural, and physiological characteristics of the organism indicated that it has never been reported. It was thought that the disease was spread by means of vaginal discharges.

Toxicity of bitterweed for sheep.—During a year of normal rainfall and range vegetation the Texas Station found that an amount of fresh green seedling bitterweed equal to approximately 1.3 percent of the body weight of sheep may be fatal when consumed at one feeding. This amount constituted the minimum lethal dose. During drought years the minimum lethal dose was much lower, approaching 0.5 percent of the animal's body weight. Feeding tests indicated that there was some increase in toxicity as the weed matured. The state of nutrition in healthy yearling sheep apparently had little, if any, effect on the animals' susceptibility to bitterweed poisoning.

"Swellhead" of sheep.—Swellhead of sheep and goats, also known as goat fever or lechuguillaed, occurs, according to the Texas Station, in regions where the lechuguilla plant is found. The condition is characterized by jaundice, liver and kidney lesions, and at times edematous swellings of the face and ears. Grazing the leaves of the lechuguilla plant during periods of unfavorable range conditions brings on this disease. It frequently causes serious losses. Two poisonous principles in the plant have been isolated and identified.

Goat lice.—Experiments conducted cooperatively with the Department of Agriculture (B.E.&P.Q.) by the Texas Station, showed that finely ground sulphur used as a dip gave excellent results in the control of goat lice. Flotation sulphur prepared by the liquid purification process, when further purified of traces of iron and arsenic sulphite left by its manufacture, gave equally good results. The formula recommended for effective control, using either of these sul-

phurs, is sulphur 10 pounds, trisodium phosphate 10 to 25 ounces, depending on the hardness of the water used, and 100 gallons of water. Two dippings at 11-day intervals are recommended.

HORSES

Cornstalk disease in horses.—The Illinois Station fed horses the artificially propagated moldlike organisms and bacteria isolated from horse brains from natural cases of the disease, and corn or corn leaves and stalks from fields in which natural cases of so-called cornstalk disease had occurred, without producing clinical symptoms. This investigation produced no clues as to the nature of the causative agent or agents of so-called cornstalk disease in horses.

Periodic ophthalmia.—The Kentucky Station made a detailed examination of the eyes of more than 500 horses and found that approximately 10 percent showed lesions indicative of periodic ophthalmia. An attempt was made to determine whether the cause of the disease was a filtrable virus by growing virus on chick embryos and transmitting the disease to horses, rabbits, and other animals through intraocular injections, as well as by other means of transmission. The results were not positive, although it was observed that animals inoculated with material from the eyes of horses, both fresh and filtered, showed a greater degree of reaction than when injected with sterile, inert liquids.

POULTRY

Coccidiosis.—Coccidiosis, one of the most troublesome poultry diseases, can be controlled, according to the Iowa Station, by feeding a ration containing adequate vitamins and vitaminlike materials for the normal development of the host. At the same time the ration should be lacking in coccidium-stimulating properties. The diet used successfully at the station for this purpose consisted of yellow corn meal, 40 parts; hulled oats, 10; ground whole oats, 5.5; barley, 5; ground whole wheat, 5; wheat bran, 5; wheat-flour middlings, 5; soybean meal, 10.5; meat and bonemeal, 4; fish meal (65 percent protein), 2; oystershell, 2; salt, 1; skim milk, 2; and alfalfa meal, 3 parts. Chicks placed on this ration at 13 days of age made excellent growth during the next 14 days and showed a low susceptibility to the disease.

After acidophilus milk had been fed for 1 month to birds affected with chronic coccidiosis at the New Hampshire Station, a fecal examination failed to show oocysts of the parasite. A condition of chronic coccidiosis was observed in association with rickets. Since there was adequate vitamin D present in the ration to prevent rickets, it was thought that the coccidia had damaged the intestinal tract to the extent that it could not absorb a sufficient amount of vitamin D to give birds normal rachitic protection. Attempts to reproduce this condition experimentally produced negative results.

Fowl pox.—Fowl pox may be transmitted to healthy birds in various ways according to results obtained at the New York (Cornell) Station. Direct contact between diseased and healthy birds is one source of transmission. In such cases, the virus may spread not only to the epidermis of the head but also to the mucous membrane lining

the oral and associated cavities. Two species of mosquitoes, *Aedes stimulans* and *A. aegypti*, were demonstrated to be vectors of the virus. Mosquitoes can best transmit the disease if they feed on pox lesions which are 5 to 17 days old. The transmission by mechanical means was indicated in that the virus remained viable on inanimate objects for at least 40 hours.

Vaccination for laryngotracheitis.—Since laryngotracheitis spreads rapidly, is easily carried from place to place, and all birds are susceptible, it forms one of the most destructive diseases of poultry. The New Jersey Station developed and tested a live virus vaccine, which, if applied when the birds are 6 to 12 weeks of age, gives after 5 to 9 days lifelong immunity to the disease.

Virus disease studies.—The New Jersey Station has employed the developing hen's egg as a means of studying viruses. This technique permits the use of a disease-free host to make quantitative and identification studies with viruses. Using this method, a virus causing bronchitis in poultry was passed through the fiftieth generation. In this time the pathogenicity of the virus seemed to have increased. Indications were obtained to show that the passage of the bronchitis virus through eggs so modified its properties that chicks inoculated with such virus usually failed to produce clinical symptoms of the disease. They were, however, subsequently immune to the virus taken directly from field cases. This indication offers promise of developing an ideal immunizing product that would be harmless, since birds or chicks so infected would not transmit the disease to a healthy bird by contact.

Internal parasites of poultry.—The Hawaii Station found for the first time that the ceca fluke (*Postharmostomum gallinum*), an important and common parasite, was transmitted by the land snail (*Eulota similaris*).

Hosts of poultry parasites.—Studies at the Kansas Station revealed that the housefly is a very important intermediate host of the chicken tapeworm (*Choanotaenia infundibulum* (Bloch)). It was also believed that this fly might serve as an intermediate host for *Raillietina cesticillus* (Molin).

Control of external parasites of poultry.—The Florida Station reports that in two experiments in which the laying mash contained 5 percent of commercial flowers of sulphur, the infestation of hens by two species of lice was considerably reduced by the end of 2 weeks and by the close of the third week none could be found. Infestations by the sticktight flea of fowls receiving similar treatment, augmented by sulphurizing the yards at the rate of 100 pounds of sulphur per 400 square feet and placing a light coating of sulphur on the floor of the houses beneath the litter, were brought under complete control in 3 weeks. Similar treatments reduced infestations of fowl tick-infested flocks. The chick mite was controlled by dusting the floor, dropping boards, and nest with sulphur. The Michigan Station found that the northern fowl mite could be effectively controlled by three applications of 40-percent nicotine sulphate to perches at 3-day intervals. Sulphur generously applied to the individual bird was also an effective control measure.

Toxicity of Crotalaria for poultry.—In experiments at the Florida Station, the force feeding of Leghorn hens with single doses of 100

Crotalaria retusa seeds caused death within 14 days and single doses of 200 seeds caused death within 10 days. Chronic cases of poisoning were induced by force feeding 10 seeds every other day, death occurring in from 18 to 40 days. A grain mixture containing seeds of *C. retusa* scattered on the ground once a day caused death in from 15 to 32 days.

GENERAL

Poisonous plants.—The Arizona Station found that intraperitoneal injections of sodium nitrate and sodium thiosulphate gave good results if administered early enough in overcoming the effects of the ingestion of such poisonous plants as mountain-mahogany, catclaw, arrowgrass, and Johnson grass. Burroweed (*Aplopappus hortweizii*) caused considerable death losses on ranges where there was a scarcity of early spring forage. *Asclepias lineria* was found to be toxic to sheep, and 40 grams of the dried plant caused death.

Suckleya suckleyana, a plant heretofore considered quite rare, was found by the Colorado Station to be widely distributed throughout the eastern part of the State. The plant grows in the vicinity of water holes and at times furnishes a very luscious forage. As high as 0.0364 percent of hydrocyanic acid has been found in the plant, which is much higher than that ordinarily present in the sorghums.

The Wisconsin Station developed a simple, fairly rapid method of determining prussic acid in Sudan grass and other forage crops. Studies showed that short, dark green Sudan grass was at times so high in prussic acid, or hydrocyanic acid, as to be dangerous to pasture. Second growth, after pasturing or removal of a hay crop, when short and dark green was especially dangerous. Sudan grass when 1.5 feet or more in height was usually low in prussic acid and was relatively safe to pasture. When the grass was of a pale or yellowish-green color it was low in cyanide poison and was relatively safe to pasture. Based on this experience the station recommends that cattle be given some other feed previous to turning into a Sudan grass pasture, when this is done for the first time during a grazing season. As an added precaution, it is a good plan to watch the herd for an hour on being turned into a field of Sudan grass. If some of the animals stop eating the grass after a few minutes or look around for other grass to eat, it is a good sign that the Sudan grass is poisonous.

Lameness in hogs fed Austrian winter peas.—Grazing hogs at the Alabama Station on Austrian winter peas with the addition of a limited ration of white corn for 5 or 6 weeks resulted in a condition characterized by a weakness in the rear pasterns which caused the hogs to "knuckle over." In some cases the weakness extended to the rump and loin, causing the animals to walk with a "reeling gait." Animals severely affected fell frequently when attempting to walk or run and sometimes were unable to rise from a reclining position without being lifted. Although the symptoms remotely resembled those of vitamin A deficiency, the Austrian winter pea plant is rich in vitamin A. It was suggested that the condition was similar to lathyrism, caused by eating certain species of *Lathyrus* peas. There have been no previous reports of such injury from eating any members of the genus *Pisum*, to which the Austrian winter pea belongs.

Selenium toxicity.—The South Dakota Station found that rations for pullets containing from 0 to 10 parts per million of selenium had no significant effect on the average feed consumption, average weight of birds, weekly egg production, or fertility of eggs. The hatchability of fertile eggs was not appreciably affected by 2.5 parts per million of selenium in the ration, but was slightly reduced at 5 parts per million, and decreased to zero by the end of 4 weeks' feeding at a 10 parts per million level. The growth and mortality of chicks hatched from eggs of hens receiving 5 parts per million were not affected. Chicks hatched from eggs of hens receiving 10 parts per million showed a relatively high mortality rate, but the growth rate of survivors was not affected. The selenium content of eggs, meat, and certain internal organs of hens receiving varying levels of selenium as supplied by toxic grains in the ration was closely associated with the selenium content of the ration fed. In experiments with rats it was found that wheat, corn, and barley ranked in descending order in their relative toxicity of this element. The female rats were less susceptible to selenium poisoning than males and the toxic effect seemed to depend more on the concentration of selenium in the diet than on the amount actually ingested daily. There was some evidence that the toxicity of grains decreased during prolonged storage. Selenium was the only one of a number of inorganic elements to cause severe liver pathology in the rat. However, when 5 parts per million of arsenic as sodium arsenite was added to the drinking water it gave full protection against the liver damage caused by 15 parts per million of selenium in the form of seleniferous wheat. The animals so fed also appeared to be free from the other characteristic symptoms of selenium poisoning. Evidence was also obtained to show that arsenic was effective in preventing liver damage and the general toxic effects of inorganic selenium.

The Wyoming Station found that seleniferous vegetation could be divided into two general groups: (1) Plants limited to a small area and capable of producing, when eaten by livestock, the alkali disease type of injury; (2) plants, chiefly weeds, occurring widely distributed and capable of producing, when eaten by livestock, the blind staggers type of injury. It was discovered that nontoxic seleniferous Steele shale geological formations could be converted to a toxic condition in less than 3 years by growing from seed some of the native seleniferous weeds in situ. Selenium in the form obtained from seleniferous weeds was found to become dispersed by leaching throughout experimental soil plats. The basal Thermopolis shales appeared to inhibit the absorption by plants of selenium in artificially selenized soils. Droppings from range livestock which have grazed upon or have been fed seleniferous vegetation were found to carry substantial quantities of selenium. Native vegetation containing selenium was apparently not so toxic as corn of lower selenium content. The treatment of livestock poisoned by ingesting seleniferous forages and weeds has been found to be practical in the early stages of the disease.

Paratyphoid bacilli.—In a study of *Salmonella typhi-murium* (*S. aertrycke*) cultures from pigeons, the Kentucky Station found certain variations in type which when compared with certain cultures of human origin indicated that the infection is transmissible to man. Dif-

ferences in cultural characteristics of specimens obtained from different outbreaks were thought to be valuable in further studies of the occurrence of this type of infection.

Endoparasitic infestations in grouse.—No seasonal variations in the degree of parasitization of grouse were found to occur in studies at the Minnesota Station. In the case of the ruffed grouse, a definite correlation between the degree of parasitization and meteorological and topographical factors appeared to occur. Infestation in different zones appeared to depend upon the mean temperature, mean precipitation, soil type, and coverage, maximum infestation occurring where the mean temperature and precipitation were highest, where the humus content of the surface soil was greatest, and where abundant coverage occurred.

Mortality in bobwhites.—In cooperation with the Department of Agriculture (B.B.S.), the Iowa Station has found that reasonably healthy bobwhites may perish through imprisonment by drifting snow. For this reason cover subject to drifting is not ideal for these birds. It was also found that exposure to cold, high winds, and snow may kill reasonably healthy individuals.

AGRICULTURAL ENGINEERING

Improvement in both the economic and social aspects of farming and farm life are contributed to in a measurable degree by the proper development and application along specific lines of pertinent engineering principles. The items which follow contain some examples of the contributions of the State agricultural experiment stations in the field of agricultural engineering.

MACHINERY AND POWER

Farm power and mechanical equipment.—To meet the demand for further development of mechanized practices along cost- and labor-saving lines and the better adaptation of available mechanical equipment to production, the stations have continued and enlarged their studies aimed at securing greater efficiency in the use of farm power.

Better use of tractors and engine fuels.—During 1937, according to the preliminary report of the Bureau of the Census, the purchase of tractors by American farmers reached the highest point since 1930, both in number and value. The number purchased for domestic use exceeded 243,000 and the value was over $184,000,000, an increase of more than 30 percent over the previous year. The trend toward the all-purpose type of tractor by American farmers is also significant, this type constituting 85 percent of the wheel tractors purchased. Of even greater significance is the fact that most of the all-purpose tractors purchased were of less than 30-belt-horsepower rating, indicating the definite tendency for wide use of mechanical power on farms in units of flexible size.

Under the circumstances, efforts to increase the efficiency of traction operations were continued and expanded by the stations, since the traction operation in all its phases, including tillage, is the largest single consumer of power. For example, the Indiana Station demonstrated the utility of 9- by 36-inch rubber pneumatic tires for a two-plow tractor pulling a two 16-inch bottom plow. A fuel sav-

ing of 11.2 percent and an increase of 13.8 percent in the acreage covered was secured with this equipment over steel wheels and lugs in ordinary row-crop farming. When pulling an 8-foot tandem disk and a 10-foot spike-tooth harrow, a fuel saving of 16.7 percent and an increase in speed of 22.9 percent were also realized with the same equipment. A three-plow tractor equipped with 11.25- by 28-inch tires and pulling a three 14-inch bottom plow gave a fuel saving of 13.3 percent and an increase in speed of 10.8 percent over steel wheels. Under adverse soil conditions, such as sandy or soft soils, tractors equipped with pneumatic tires were more satisfactory for operating combines than were steel-wheeled tractors of the same size, according to the Indiana Station. Small, lightweight combines on rubber tires could be operated over soft soil during soybean harvest when the larger combines could not be pulled through the field. Thus, the use of pneumatic tires for traction and other machinery in farming is reaching the stage where not only power and time are saved but it is now possible to specify the size and internal pressure of tires which will perform a given traction operation on known soil type and condition at a maximum saving in fuel and time.

The large amount of liquid fuel consumed by the more than 1,000,000 tractors now on American farms has resulted in a steadily increasing demand for cheaper tractor fuels and more specific information as to their economical use. The stations have recognized that economy in fuels relates both to their character and the manner in which they are used, these being governed to a considerable extent by the particular job or farming practice concerned. Typical of recent studies are those at the Kansas Station where the essential characteristics of a satisfactory distillate for use as a tractor fuel have been determined. The station is now able to recommend minimum specifications for a satisfactory distillate fuel intended for use in the conventional modern low-compression tractor. These include a gravity rating of not below 38° of American Petroleum Institute units; initial point not above 360° F.; 10-, 30-, 50-, 70-, 90-, and 95-percent points not above 390°, 420°, 435°, 450°, 480°, and 550°, respectively; an end point not above 540°; octane rating not less than 30; and a sulphur content not over 0.2 percent. Studies of Diesel fuels by the Nebraska Station, in connection with tractor testing under the provisions of the State tractor-testing law, have recently resulted in modernized specifications which recognize important fuel characteristics not previously specified. The minimum flash point is now 150°, and the allowable sediment and water contents have been reduced from 0.5 to 0.05 percent, indicating that clean fuel is an important factor. A limit has been placed on the carbon residue and the ash, the pour point is designated, and the ignition quality is being given attention. The allowable sulphur content has been raised from 1 to 2 percent.

Problems of utilization of tractors on specific draft and belt operations as they affect the economy of fuel use are also receiving attention as potential cost-saving lines of investigation. The Kansas Station has studied the economy of use of power, fuel, and time on contour, and uphill and downhill farming, using two- and three-bottom plows, tandem disk harrows, duckfoot field cultivators, wheatland disk plows, damming listers, and several different types of

tractors in various combinations. An average of all tests in which uphill and contour travel were in the same gear, either second or third, showed a time advantage of 1.8 percent and a fuel saving of 6.4 percent for the contour. However, the average results of all uphill and downhill draft tests were practically identical with the average results of all contour draft tests at a speed of 3 miles per hour. The power requirements, and consequently the fuel utilization, were greater on the contour than on uphill and downhill travel. Similar work by the Iowa Station, in cooperation with the Department of Agriculture (B.A.Eng.), has been successful in introducing power- and labor-saving methods into the field operations involved in corn production. In line with the understanding that operating costs in corn production depend largely upon the efficiency of labor, power, and machinery management, a plow has been designed and adjusted to cover trash. Its use in seedbed preparation has been found to eliminate the necessity for disking before plowing, cutting stalks, and raking and burning stalks, resulting in appreciable cost saving. The superiority of the lever type of spike-tooth harrow over other machines for light operations in seedbed preparation has also been demonstrated. Drill planting has been found to be a faster operation than check planting, but weeds are more difficult to control with the former. A cultivator equipped with a pair of rotary-hoe wheels near the row and six sweeps between rows was developed which has given the best results for early cultivation of surface-planted corn, and for cultivation of weedy corn a cultivator equipped with two pairs of disk hillers and one pair of sweeps per row gave best results. It was demonstrated that harvesting a 70-bushel-per-acre yield of corn required 2.5 man-hours of labor per acre when done by machine as compared with 9 man-hours of labor when done by hand. A 7-year study was completed and published by the Montana Station showing how efficiency may be attained in the operation of tractors and implements in general farm operations. According to these studies, tractors in general farm work operate most efficiently near their rated capacity and for best economy should always be loaded up to nearly a full load. Thus, light-draft implements should be hitched in gangs of two or more to make an economical load for the tractor. Tillage implements should be operated as deeply as is necessary to kill weeds, but no deeper for economy in use of tractor power. A saving of 60 hours per acre of hoe labor by normal cultivation of cotton land over land receiving no cultivation was demonstrated by the Mississippi Station.

More efficient tillage methods and equipment.—Tillage continues to be the largest consumer of draft power of any of the power-consuming farm operations. While the stations have devoted much study to the subject, it is among the least solved of agricultural problems. Since soil tillage involves the relationships of metal surfaces and the dynamic masses of the soil, the problem has been approached through the study of the dynamic aspects of soil. The Alabama Station, whose work in recent years has been cooperative with the Department of Agriculture (B.A.Eng.), has been able to elucidate the nature of the physical forces that govern the adhesion of soil through its solution to the metal surfaces of plows and other tillage tools, thereby adding to the meager knowledge of how best to shape a plow,

of what material to construct the surface of the moldboard, how to heat-treat and alloy the moldboard metal, and how to polish the surface so that in certain soils the plow will function with a maximum of efficiency as a tillage tool but with a minimum consumption of power. In a study of a large number of standard plow steels, special alloy steels, and irons, it was found that differences in grain structures of metals with the possible differences in potential between the various grains materially affected the tendency of soil solutions to adhere to the metal surfaces. The presence of alloying materials in steels and even in cast iron was frequently accompanied by a considerable decrease in adhesion. On the other hand, metals containing free graphitic carbon, such as cast iron, had a great attraction for soil solutions, resulting in greater adhesion. It was also determined that grain size and other structural differences, due to heat treatments, affect adhesion, which seems to decrease with increasing hardness of the metal. Since the relationship between adhesion of soil to metal surfaces and draft of plows is well known, it seems that the solution of the tillage draft problem, as it is affected by nonscouring and friction, is rapidly nearing completion.

An important tillage problem in many localities is that where stones or roots are frequently encountered, particularly during the cultivation of row crops. To correct the deficiencies of available cultivating equipment the Pennsylvania Station developed spring teeth for cultivators. The flexibility of this equipment, however, frequently caused it to shrink from hard going and dodge well-rooted weeds. These difficulties have been remedied by the development at that station of a type of spring trip.

More efficient mechanical fertilizer placement.—Farmers in the United States during 1937 again used approximately 8,000,000 tons of fertilizers. The stations continued their efforts to develop mechanical methods of application which would reduce labor costs and at the same time result in placement for maximum effectiveness and minimum injury to plants.

The investigations of the North Carolina, South Carolina, and Texas Stations, on the mechanical application of fertilizers on cotton, were cooperative with the Department of Agriculture (B.A. Eng.). The North Carolina Station showed that maximum benefit from normal and higher rates of fertilizer applications can be assured under soil conditions of the State by placement from 2 to 3 inches to the side and from 2 to 3 inches below the level of the seed. Placement to one side of the seed gave practically as good results as application to both sides. To avoid injury with a normal or heavy fertilizer application, high in nitrogen or potassium, the seed should not be placed too close to the fertilizer.

In the South Carolina experiments it was found that the final stand of cotton plants was better when planting was done with a combination planter and disk-type distributor, developed by the Bureau of Agricultural Engineering, than where the common walking type of planter was used. The Texas experiments again showed that of all placements of fertilizer the best germination of cottonseed and the highest yields were obtained when the fertilizer was placed to the sides and below the seed level. The location of the fertilizer in relation to the seed apparently affects germination more than yield. More

plants are obtained where one-fourth of the fertilizer is applied to the surface soil over the seed and the remainder placed 2½ inches to each side and 2 inches below the seed level. The highest yield was obtained where one-eighth of the fertilizer was placed with the seed and the remainder 3½ inches to each side and 2 inches below the seed level. Disturbing the soil at any depth under the seed without applying fertilizer reduced the final stand of plants.

Better mechanical planting of field crops.—Both the cost of seed and the labor cost of planting have been taken into consideration in investigations aimed at the development of mechanical methods and equipment for the planting of field crops. It has been found that these factors are important in securing maximum germination and stands. At the Ohio Station efforts have been continued to establish some means by which seedsmen and farmers may determine quickly which corn-planter seed plates to use for each grade of seed at hand and for the make of planter available. Seed plates were arranged according to seed-pit volumes within the groups differentiated first on the basis of general shape of seed pit. This method gave considerable promise as a practical index with plates that are not beveled. The Iowa Station demonstrated the superiority of surface planting of corn over the use of disk furrow openers under ordinary soil conditions. Under favorable growing conditions narrow spacing and single-plant hills produced a material increase in yield over that obtained by the usual method of check planting. Corn seed drilled in a continuous row without any synchronization with location of dams did as well as any other placement of seed. The station also determined that it is possible to combine planting with the last seedbed operation by mounting a cultivator on the tractor that is used to pull the planter, the cultivator being equipped with sweeps that will thoroughly cultivate the surface without ridging.

Mechanical harvesting.—Many of the stations have engaged in studies of the development of mechanical equipment and methods for efficient harvesting of crops. In view of the large labor- and cost-saving possibilities, farm-machinery manufacturers have been quick to take advantage of such developments. Many new problems have been encountered in the harvesting of seed of different crops in a manner to retain high percentage germination by reducing mechanical injury to a minimum. Typical of this work is that of the California Station on the development of details of a satisfactory seed-bean thresher. A rubber-roller machine was developed which proved satisfactory in the threshing of practically all of the baby lima beans and other small beans encountered in the interior valleys of California. This machine was developed further so that it would thresh a satisfactory percentage of large beans, such as the Fordhooks. Typical of studies leading toward the further development along lines of efficiency of the combine harvester for the harvesting and threshing of small grains were those at the Ohio Station where several years' experiments have been completed. This work covered machines of sizes ranging from 5 to 12 feet, it being found that the small 5-foot machines have as high a capacity as either the 6- or 8-foot machines and usually travel a little faster. Evidence also was obtained that if a combine is to work efficiently in weedy, as well as

in clean crops, the cylinder must be of such type and adjustment that it will not break up the material any more than is necessary to get the grain out of the heads. Otherwise, straw racks and grain shoes of present design will become overloaded, resulting in tremendous losses of grain. The Indiana Station found that with proper adjustment of cylinders, the small combines with 5- and 6-foot cutter bars harvest as satisfactorily as the larger machines under similar conditions. The station also demonstrated the economy of cutting corn with a field silage harvester and hauling by motortruck to a blower at the silo. The higher machinery costs of the field silage harvester are more than offset by the saving in man labor.

According to the Georgia Station, crimson clover as a winter legume is becoming increasingly popular in the South, particularly in Georgia, one of the big advantages of the crop being that farmers can produce seed and save it for planting purposes. Recognizing the mechanical problem involved, the Georgia Station has developed a low-cost crimson clover-seed harvester that can be built on the farm or in almost any blacksmith shop. This machine harvests the ripe seed in the chaff without cutting the plants, thus allowing them to remain on the land for soil improvement. This method of harvesting is especially desirable for the farmer producing seed for home use and for local growing, since, on the average, better stands can be secured by planting in the chaff than by planting clean seed. In addition, only ripe mature seed are gathered that can be stored without danger of heating. The machine can be constructed from the frame, platform, wheels, and a number of other parts from a discarded grain binder. The cotton harvester developed by the Texas Station has been further improved so that it has harvested 97 percent of the cotton from 7 varieties in east Texas and 98.8 percent from 13 varieties in northwest Texas. Burrs, green bolls, green leaves, and trash were removed with an extractor mounted with the harvester on the same tractor.

Mechanical curing and processing of feeds.—The problem of retaining digestive properties as well as nutritive quality in processed feeds, particularly grains and forages which have been cut and ground, is ever before the stations. It is being demonstrated that an economic balance exists between the cost of grinding of feeds to certain degrees of fineness and the nutrition and digestive advantages gained thereby. The hammer mill has been developed to a high degree of efficiency and economy for this purpose. The work at the Wisconsin, Ohio, and Kansas Stations particularly has shown the possibility of grinding feeds to a fineness which will meet certain specific needs as to nutrition and digestibility and at a minimum cost. This has necessitated the development of special types of grinding machinery for some localities, particularly where farmers of moderate or low income predominate. To meet this special need investigations at the Tennessee Station have resulted in the development of a small automatic hammer mill which is 4 inches wide, has an 11-inch swing of 10 hammers, has semiautomatic tangential feed, and may be belt- or shaft-driven by a ½- to 1-horsepower motor. This hammer mill is capable of grinding oats, shelled corn, barley, and other small grains for stock feed, and can be used to grind corn meal and whole-wheat flour for home use. While small hammer mills of this type

apparently are not so efficient as the larger grinding units, their efficiency has been shown to be equal to any other type of mill of equal capacity. It appears that the advantages of the small investment to the type of farmer who can use this size of mill effectively more than offsets the loss due to lower efficiency. The grinding, mixing, and elevating of feed has been developed by the Washington Station to a point where the cost of hauling the grain from the farm to a commercial mill and back can be saved. Feed grinding has become a spare-time job of a type which eliminates the necessity for a large storage space for ground grain, because grinding can be done as needed.

Stationary spraying equipment.—Further efforts to increase the efficiency of stationary spraying equipment are reflected in the finding by the Indiana Station that the entire cost of a stationary plant can be paid in 5 years by the savings in the cost of applying sprays. It was found, in addition, that permanent equipment of this character was in good condition after 6 years' use, whereas portable equipment was practically worn out.

EROSION AND RUN-OFF CONTROL METHODS AND EQUIPMENT

The development of measures for the control of run-off and soil erosion has been undergoing refinement by the stations in cooperation with the Department of Agriculture (S.C.S.). The economic aspects of the problem and the necessity for adaptation of control measures to specific types of adjusted practices in farming as well as improved cultural practices have received recognition. For example, good crop rotation, adequate cultural treatment of soil, and proper land use should accompany terracing, according to the Missouri Station. It is found that when terraces are used in this way the combination of methods can be expected to prevent at least 92 percent of the soil losses on medium to long slopes. The terrace proving best suited to agriculture in Missouri consists of a combination of a ridge of soil and a channel built sufficiently wide, on moderate slopes, to be crossed easily with farm implements. It is constructed by placing earth above the ground line in a ridge at right angles to the land slope, with most of the earth taken from a broad channel cut on the uphill edge of the ridge. Terraces are spaced on the slope so as to prevent excessive soil movement between them where a good supply of organic matter is kept in the soil. They must be built with sufficient height to prevent run-off water overtopping them, and given just enough grade in the channel to allow excess run-off water to flow from the field at a nonscouring velocity. The Indiana Station demonstrated the utility of mangum terraces in diverting run-off from a badly gullied area, thereby permitting the reestablishment of grass cover on the gully banks below the terraces. This combination of mechanical and vegetative control arrested erosion on a badly eroded area. A contour furrowing plow for use in pasture land has been developed by the Missouri Station. This plow lifts up the sod and topsoil, makes a ridge beneath, and then drops the undamaged sod back into place. It exposes little subsoil and tears up a minimum of sod. Contour furrowing of pasture land saves approximately 24 percent of the total rainfall and increases the carry-

ing capacity of the pasture in proportion, according to the station's experiments, and the new contour-furrowing plow overcomes the difficulties of destroyed sod and exposure of subsoil. A reversible rotary terracing machine equipped with hydraulic lifting and reversing mechanisms has been perfected by the Iowa Station. Tests of this machine have demonstrated its superior efficiency and ease of operation.

Greater emphasis is being placed on the fundamental aspects of erosion and run-off control by the stations and the Department of Agriculture, in view of the economic necessity for close coordination of modernized land use and soil conservation practices. For example, a study of run-off and soil erosion on Putnam silt loam soil of varying condition and slope just completed by the Missouri Station shows that the relative density of the run-off material increases with both the degree and the intensity of the rainfall. Soil losses from a saturated soil are found to increase with the 0.7 power of the slope, with the 2.2 power of the rainfall intensity, and directly with the duration of rainfall. From one and one-half to two times as much run-off is required to remove a pound of soil at the end of 1 hour as at the beginning of rain. Soil in a dry pulverized condition or in a dry rough condition absorbs much more rainfall water than soil in a smooth, hard, baked condition. Apparently infiltration is not affected by either slope or rainfall intensity but varies inversely as the initial soil-moisture content.

Similar studies at the Georgia Station have drawn a relationship between losses of soil, moisture, and plant nutrients, and six different land-use practices on Cecil sandy loam soil with a 5-percent slope. Under such conditions the maintenance of some sort of vegetative cover on the soil throughout the year was demonstrated to be the major necessity in order to hold soil and water losses to a minimum.

STRUCTURES

Improved farm buildings and structural equipment.—In line with modern farming policies the need for buildings and structures of permanent character and of maximum utility and efficiency is being recognized by the stations more than ever before. The investment in structures used in commodity production continues to be among the largest in the farming industry. Modern long-time planning in farming therefore calls for structures which will show a reasonable return on the investment over an appreciable period of years.

Better farm homes.—The need for more adequate housing for farm families, particularly among lower-income groups of farmers, is recognized by the stations. The Federal farm-housing survey revealed that in Georgia, for example, 25 percent of the farmhouses were below minimum standards for human habitation. A study by the Arkansas Station of more than 200 farm homes in 67 counties of Arkansas demonstrated that the labor of the farm family and available native materials, if properly combined through planning, may be utilized in providing more nearly adequate housing for rural families in that State. With the same general objective the Georgia Station and the Department of Agriculture (B.A.Eng.) have cooperated in efforts to develop more satisfactory types of low-cost con-

struction for farmhouses. Already certain details of a practical character have been established. For example, the use of cottonseed hulls as insulation seems to be practical, and a fire-resistant treatment for these materials has been developed for which the cost of chemicals required is approximately 0.1 cent per square foot of a 4-inch thickness. Valuable contributions on several phases of farm-home improvement have also been made by the Missouri Station, including the development of adequate protection for farm-home water supplies, simplification and reduction in cost of adequate sewage-disposal systems, planning of room arrangement and equipment for improved lighting, and the development of plans for over-all low-cost farmhouses specifically adapted to Missouri farm conditions and locally available building materials.

Rammed-earth construction.—Progress in the development of rammed earth as an economical building material for farm structures has been accomplished by the South Dakota Station, especially in the development of protective coverings for rammed-earth walls. A good beginning also has been made in the development of rammed-earth building blocks. The use of cinders in this material to reduce the percentage of clay colloids has improved its structure. The insulating properties of rammed-earth walls are in proportion to their thickness, according to the South Dakota Station. A 14-inch wall is adequate for poultry-house construction at 44° north latitude. Earth walls also may be rammed successfully at temperatures as low as +15° F., provided the soil is of proper quality and warm (60° to 70°) when rammed.

Crop storages.—The problem of proper curing of crops and of retaining quality by proper storage has been widely recognized by the stations. It is now becoming possible to hold many crops of a perishable nature in storage sufficiently long to take advantage of better prices.

Grain storages.—Development of curing methods and storage equipment for grains is permitting timeliness and greater economy in harvesting operations. Grain-storage investigations by the Maryland Station, for example, which are cooperative with the Department of Agriculture (B.A.Eng.), have demonstrated that wheat harvested and threshed with a moisture content of 16 percent or more cannot be safely stored in any known form or type of bin without first being treated. Bin insulation and ventilation are useful practices, but the most promising results have been secured from the use of absorptives as drying agents.

Vegetable and fruit storages.—The seed-potato industry is quite important in several localities, but its success depends to a considerable extent on ability to carry the seed potatoes through to the time when they can meet the market at the most advantageous price. The experiment stations have recognized the storage and curing problem involved, and have devoted considerable investigation, particularly to the influence of storage temperature on the seed value of potatoes. Field studies by the New York (Cornell) Station to determine the effects of various methods of storing seed potatoes on subsequent plant growth and yield showed that low humidity in storage results in the least sprouts per seed piece but in the longest individual sprouts. The most sprouts appeared on tubers stored at 40° F. and

later shifted to 50°. The final stand of plants usually was lower from seed stored at 32° than from that stored at higher temperatures. From this it may be drawn that in localities where early planting usually results in highest yields it is desirable to store seed at the higher temperatures so that sprout growth at planting time will be as large as possible. Studies at the Nebraska Station under entirely different conditions showed that cold storage from harvest to planting results in less weight loss and in a higher percentage of sound potatoes than does cellar storage. With late June planting, emergence is slightly slower from cold-storage than from cellar-storage potatoes, but the stands and total yields are better.

A basis for the design and operation of common potato storages adapted to regions where the average winter temperature is from about 20° F. downward has been evolved by the Department of Agriculture (B.A.Eng.) and the Maine and Michigan Stations working in cooperation. It has been demonstrated that temperature and moisture control effected mainly by conduction of heat and condensation of moisture on waterproofed surfaces is better than control effected mainly by ventilation.

The sweetpotato industry, particularly in the South, depends to a considerable extent for its success on proper storage and curing. The industry in the State of Louisiana, for example, is valued at approximately $7,000,000 annually. According to results obtained at the Louisiana Station, the keeping of sweetpotatoes in storage differs little as to amount of shrinkage or rot whether or not artificial heat is provided. In the Sunset district, large quantities of sweetpotatoes have been stored in buildings similar to warehouses, and the roots themselves seemed to provide enough warmth during cold spells to obviate artificial heating during storage. According to the Georgia Station, the main cause of damage to sweetpotatoes during curing results from uneven heat distribution which may be caused by the type and location of the heating equipment or a lack of adequate ventilation. The station has demonstrated that a well-built and tightly constructed house with controlled ventilation is most desirable for the storing of sweetpotatoes under Georgia conditions. Houses with wood interiors are preferable because they are easier to keep dry and are usually cheaper to construct. It has been found that a tobacco-barn furnace and flue that gives even heat distribution is conducive to a more uniform temperature and evaporation than is a stove located below or above the floor. The location of the stove or furnace outside the house is desirable so long as the heat is delivered through a pipe into the house. The station has developed plans for an efficient storage house for 500 bushels of sweetpotatoes.

Storage of other fruits and vegetables on the farm is becoming a problem of increasing economic importance. Until recent years practically all such farm storage was done in cellars of one type or another. Typical of work done by the stations to meet this situation is that at the New York (Cornell) Station where refrigerated small storages for fruits and vegetables have been developed on a reasonably satisfactory basis. The Massachusetts Station has issued practical instructions on the construction and operation of refrigerated apple storages and has established the limits of reasonable cost of operation.

Improved animal shelters.—The improvement of animal shelters is involved in studies by the Illinois Station in cooperation with the Department of Agriculture (B.A.Eng.) on the energy requirements and heat production of swine. These studies have evolved basic data suitable for use in the design of adequate hog-house ventilation systems.

Improved and cheaper building materials.—The large outlay for farm structures requires that full advantage be taken of all local building materials and of every means of increasing durability and serviceability. The extent to which agricultural wastes may be utilized to advantage as loose-fill building insulation depends largely on the amount of moisture present, according to the Iowa Station, whose studies have shown that treatment of the inside of a wall with two coats of asphalt brought about a pronounced reduction in the rate of moisture accumulation. Durability of wooden shingles is of considerable economic importance in farm-structure maintenance. As a result of 25 years' study the Pennsylvania Station demonstrated that preservative treatment of wood shingles with creosote increased the life of the shingles and improved their physical properties. Shingle nails also lasted longer under such treatment, thereby lengthening the useful life of a roof.

Much has been done to increase the useful length of life of structural timbers. Methods of treatment of both hardwoods and softwoods have been developed by the Minnesota Station which take into account the permeability of these woods as a basis for the most economical as well as effective treatment. The results of 25 years' study at the Missouri Station have demonstrated that white oak, black locust, white walnut, and sassafras respond best to preservative treatment which increases the length of service from three to four times that of untreated posts.

IRRIGATION

Improved methods and equipment for farm irrigation.—The need for meeting crop requirements for water under both arid and humid conditions has caused the stations to continue efforts to develop principles governing the best utilization of water for irrigation. Two new devices for measuring and recording the delivery of irrigation water to farmers were developed by the Colorado Station. These include an adjustable tube orifice meter for measuring the rate of flow in channels of flat grade where the velocity is low and the available head for measurement limited, and a meter capable of summing up the total flow in acre-feet through the Parshall measuring flume or free flow over weirs. A new and effective device for removing the bed load from canals and ditches has also been developed by the station in cooperation with the Department of Agriculture (B.A.Eng.). Sprinkler irrigation with portable equipment is being developed by several of the stations in both semiarid and humid regions. The California Station completed 170 sprinkler-distribution tests which showed that to obtain maximum coverage a sprinkler should rotate not faster than one revolution per minute. The most uniform distribution results from a conically shaped pattern where the application is a maximum at the sprinkler and tapers off uniformly to the

edges of the area wetted. Sprinklers with this type of pattern should be spaced fairly close together along the line and not more than 60 percent of the diameter should be covered in the other direction. In planning small sprinkler irrigation systems it was demonstrated to be good practice to proportion the pipe sizes and nozzle sizes so that the over-all pressure ratio does not exceed 1.2. It was also shown that the average operating cost on 22 such systems operating with double lines was 51 cents per acre-inch for labor and 20 cents for power, exclusive of depreciation and maintenance. For 17 systems with single lines these costs averaged 72 cents for labor and 26 cents for power. These and other studies have indicated that portable sprinkler systems are generally satisfactory in areas with a high water table for irrigating spring crops, such as peas, that require only one or two light applications in addition to the normal winter rainfall. They are especially well adapted to irregular topography and shallow or coarse-textured soils of low water-yielding capacity that require light applications at frequent intervals. The feasibility of sprinkler irrigation of pastures for dairy cows was demonstrated by the Oregon Station, resulting in a steady expansion of this method of irrigation for both vegetable crops and dairy pastures. Sprinkler irrigation with portable rotary equipment is on the increase in humid sections according to the Wisconsin Station, which has issued instructions on the selection of efficient and economical pipe-distribution systems. Porous-hose irrigation under humid conditions also has been developed to a high degree of efficiency. The Indiana Station demonstrated the value of supplementary irrigation of inbred lines of corn by this method.

ELECTRIFICATION

Use of electricity in agriculture.—During 1937 nearly 200,000 additional farms received electric service for the first time, so that at the end of 1937 over 1,240,000 farms were connected to central-station service. The work of the stations was directed to increasing the total efficiently used electrical load as well as the efficiency with which electricity is being used now.

Electricity in poultry production.—The New Hampshire Station has completed 4 years' work, indicating that electrical brooding is now on a practical basis and can be carried on under very severe climatic conditions without auxiliary heat or excessive mortality. It was found that a double wood floor with a disk of 1-inch insulation board properly waterproofed and placed on the floor under the brooder is just as good as built-in insulation and is less expensive. Preheating of fresh litter is recommended. Increasing the square area and cubic contents of a brooder by the addition of extension rims and extra curtain without changing the chick load or heating element was of material benefit in stabilizing temperature control under the brooder. To reduce mortality it was demonstrated that not more than 200 baby chicks should be placed under a 52-inch square electric brooder and not more than 225 chicks under a 56-inch round electric brooder.

Electric heat for laying houses was shown by the Idaho Station to be economically feasible in houses that are well built and well in-

sulated. Brief specifications were issued for an electric heater for use in laying-house service. These call for an automatically controlled heater having a 1,000- to 1,500-watt heating element equipped with a fan capable of circulating from 200 to 225 cubic feet of air per minute. Such a heater has sufficient capacity to warm the air of an insulated laying house 20 by 40 feet in plan and having a volume of approximately 5,000 cubic feet. From 100 to 150 watts should be allowed for every 500 cubic feet of volume.

The influence of poultry-house lighting on egg production is obtained through light absorption rather than through exercise and feed consumption at night, according to the Ohio Station. It was determined that it is the long red rays of light that stimulate birds to reproductive activity. Better results were obtained by reflecting the lights on the roost than on the floor. While 10- and 25-watt lamps were too small, it appeared that a 40-watt lamp produced as good results as a 100-watt lamp.

Pig brooders.—As developed by the California Station electric pig brooders were successful in reducing the loss of pigs during the first 10 days after birth, the reduction being about 50 percent over a period of 3 years. There was practically no difference in results obtained with under-heat and radiant-type brooders, although the radiant type showed certain advantages in cost and operation. The initial and operating costs of the brooders apparently are low enough to make their use economically feasible.

Hotbed heating by electricity.—Much has been done by the stations to introduce greater efficiency into the use of electricity in hotbeds and at the same time produce optimum biological results. For example, the location of the heating cable in the soil surface of a hotbed is the most satisfactory for all factors concerned, with the exception of energy consumption, according to the Washington Station. A lower energy consumption without appreciably lowering efficiency in other respects is obtained by pressing the cable down until it is buried under 0.25 inch of soil. Placing the heating cable on top of the soil eliminates the necessity of heating large quantities of soil and the possibility of plant freezing, according to the Pennsylvania Station. It also eliminates the necessity for drainage of the hotbed and the need for insulation at the bottom of the bed, thereby simplifying the use of heating cable and reducing cost of operation. In using electric cable for early plant propagation the station recommends the use of a mixture of half-and-half growing soil and sand for uniform heating, as sand appears to be a good heat conductor and gives uniform heat distribution. The use of electrical bottom heat in propagation by seed and by cuttings has been developed by the Georgia Station to speed rooting and to increase the number of cuttings taking root. It appears also that the process usually results in a higher and much accelerated germination. Calculating current consumption on a row basis the station showed with *Begonia* that 30 days were saved in the time of rooting at an expense for electricity for 100 cuttings of a little over 7 cents.

Electric insect control.—The development of means for trapping and destroying insect pests by light attraction and electrocution is assuming considerable importance in station work. Investigations of the effect of light traps in apple orchards conducted by the New

York Stations and the Department of Agriculture (B.E.&P.Q.), showed that they exerted an influence on codling moth infestation sufficient to be reflected in a measurable decrease in injury to the fruit. The control secured by light traps was comparable to that secured by the application of two cover sprays of lead arsenate. The effectiveness of bait traps for the codling moth may be greatly increased by suspending them underneath 75-watt lights, according to the Pennsylvania Station. The station showed that a trap costing $1.50 and consisting of a light and reflector suspended above molasses-water bait is more effective in killing adult codling moths than an electrocuting light trap costing $15. However, the efficiency of insect electrocuting light traps was demonstrated by the California Station in the control of the grape leafhopper, artichoke plume moth, codling moth, lima bean pod borer, and insect pests of tomatoes, mushrooms, and dried fruits. In mosquito-control investigations the New Jersey Station demonstrated that blue light from a tube filled with mercury-argon vapor had superior attractive power over white, red, and greenish-yellow lights.

FOODS AND NUTRITION, EQUIPMENT, AND ECONOMICS OF THE HOUSEHOLD

"Better Eating, Better Health, and Better Living" might well be the slogan of the experiment stations where research studies are being carried on which deal with the rural family's food and the nutrition of the members of the family, the house and its equipment, and the standards of living of the family. The few examples noted below have been selected to illustrate the progress made during the past year.

FOODS AND NUTRITION

The specialists in food research have been engaged during the year in many different types of work, ranging from the analytical studies on the chemical nature of the food constituents to the routine cooking tests that are such an important part of any study in which the quality of food products is under investigation. The development of improved methods of preserving and storing foods, and preparing them for the table represents the major part of the studies in progress or just completed in the field of food research. In a few experiment stations progress has been made in finding new uses for some agricultural products. In nutrition research the progress made by the groups participating in the regional cooperative projects on nutritional status of young women, which were reviewed in the 1937 report, is sufficient proof that by such concerted effort a great deal more can be accomplished than by working separately in applying to large groups of the population the results of laboratory and clinical research in nutrition. Research investigations with animals as experimental subjects have revealed the effects, such as rickets, pellagra, anemia, and scurvy, of specific dietary deficiencies. The dietary studies have shown that many groups are inadequately fed. The present trend is toward more fundamental research in human nutrition by studying the relationships between diet and creative effort, between diet and health and vitality, and between deficiencies of agricultural production, wealth, and human welfare.

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FOODS

Food preservation by freezing.—With the advent of the storage-locker plant in many rural communities, and more recently of the refrigerator containing a separate storage section for frozen foods, a number of experiment stations have been studying methods of freezing, storing, and cooking frozen-pack foods. The New York State Station has worked out simple methods for the preparation and freezing of fruits and vegetables intended for storage in lockers. In view of the fact that the spores of bacteria and fungi as well as the growing micro-organisms are not all killed either by hot blanching or by freezing, the wise homemaker is unusually careful in preparing home-grown foods for preservation by freezing. The precautions noted by the New York State Station include a consideration of variety, maturity, and freshness in selecting the vegetables and fruits, and, if they cannot be prepared for freezing immediately after harvest, in keeping them in a cellar, ice house, or some other cool place. Frozen fruits are mostly eaten raw for dessert and therefore cannot be subjected to heat before freezing to inactivate the enzymes as is done with vegetables. The addition of sugar or sugar sirup is the method used to slow up enzyme action and deterioration, but since some time is required for the sugar to penetrate the fruit the quick-freezing method used for vegetables offers little advantage for fruits. The station recommends packing the fruit with sugar in small containers and placing it in cold storage maintained at 0° F. or below, with a free circulation of air. Peas, lima beans, spinach, asparagus, sweet corn, snap beans, strawberries, sour cherries, currants, cranberries, blueberries, and peaches may be successfully frozen for locker storage using the methods advised by this station.

At the Washington Station a study in cooperation with the Department of Agriculture (B.C.&S.) was begun in 1936 to determine the adaptability of different varieties of vegetables to freezing preservation and, to date, the specialists in food preparation have made cooking tests on almost 300 varieties of frozen-pack vegetables. While no fine distinctions relative to quality factors can be drawn from the limited data now available, the general results confirm previous findings that selected varieties of peas, bush and pole snap beans, and early-maturing sweet corn are well adapted to freezing preservation. For example, of 82 varieties of peas packed by the frozen method and tested by cooking in boiling water for 7 minutes, about 35 are classified as "well adapted," "promising," or "worth further trial," and 9 are already being frozen commercially with excellent results. Of 26 varieties of snap beans, 24 were found to be well adapted to freezing preservation.

Food preservation by canning.—One of the most important food problems—the effect of the canning process on its nutritive value—continues to be an interesting research study. According to investigations carried on at the Massachusetts Station, canning destroys from 50 to 85 percent of the vitamin C content of peas, lima beans, spinach, and green asparagus as compared with about 30 percent lost during the commercial freezing process.

Apparently the acid in tomatoes protects them from loss of vitamin C during canning, as well as during storage, shipping, and market-

ing. The same varieties of the 1936 crop of tomatoes which the Massachusetts Station reported to be good sources of vitamin C were also high in 1937 when compared with other varieties, but all contained from 20 to 30 percent less of the vitamin, indicating that seasonal as well as varietal differences may greatly alter the vitamin C content of commercial and home-canned tomato products. Partly ripe tomatoes contained as much vitamin C as did freshly picked or stored ripe tomatoes. The Massachusetts Station also found no significant loss in vitamin C in tomatoes canned either in glass or in tin when stored for about 4 months in reduced light at room temperature. The Florida Station found that home-canned tomatoes and tomato juice preserved according to the directions given out through the extension home demonstration agents contained as much vitamin C as five different commercial brands.

Tomato juice canned in glass bottles and in tin cans in a commercial plant lost about 10 percent of its original vitamin C content during processing and an additional 10 percent during 40 days' storage, with no further loss occurring during the remaining 190 days of the storage period. The explanation given by the New York State Station workers who made the tests is that since the juice was not deaerated it contained some dissolved and entrapped air that caused some loss of vitamin C during the processing and a further loss during the first few weeks of storage. During this period the oxygen was entirely used up and therefore no loss of vitamin C occurred afterward. The greater the head space in the glass bottles the greater was the loss of vitamin C occurring in the juice during cooling and storage. No appreciable difference was noted in the vitamin C content of the completely filled glass bottles and tin cans at any time during the storage period. The evidence presented suggests that vitamin C is not lost more rapidly from tomato juice packed in bottles filled completely than from tomato juice in tin cans similarly filled, but the loss is considerable if the bottles are only partially filled.

Food storage.—Storage problems of foods that have not been preserved by freezing or by canning have also received attention. For lengthening the cucumber season the Texas Station recommends wrapping the ripe cucumbers individually in moistureproof cellophane or packing them unwrapped in a basket or crate lined with the cellophane and storing them in an electric refrigerator at a temperature between 35° and 40° F. According to the score cards of the panel of judges, the cucumbers remained for 8 days practically as desirable as when freshly harvested, and for a period of 2 weeks were acceptable although not in choice condition.

The best storage conditions to retard the staling of bread are a temperature close to 42° F., with the bread wrapped and sealed in wax paper at the end of a 1-hour cooling period after removal from the oven. When this procedure was followed at the Minnesota Station the bread remained quite fresh for a period of about 4 days. The most rapid staling took place during the first 8 to 12 hours after the loaves were removed from the oven. It is of interest to note that the addition of soybean flour to the bread dough delayed the staling process for an additional 24 hours. Also, the bread made from semi-hard-wheat flour staled less rapidly than did bread made from soft-

wheat flour, indicating that protein characteristics may be one of the factors involved in the staling process.

Food preparation.—In the preparation of foods for the table the best methods are those that ensure the greatest retention of flavor, color, and palatability as well as nutritive value. With the output of vegetables preserved by the frozen-pack method on the Pacific coast increasing from about 12,000,000 pounds in 1936 to 20,000,000 pounds in 1937, the Oregon and Washington Stations are studying the best methods of preparing frozen vegetables for the table. So far as the vitamin C content is concerned, the Oregon workers recommend cooking frozen-pack peas in the top part of a double boiler. When the peas are thawed at room temperature before cooking, more of the vitamin C content is lost. The greatest losses were found to be due to the solubility of the vitamin C in the cooking water, with the length of the cooking time, the temperature at which the peas were cooked, and the length of time they were allowed to stand before cooking all exerting some influence. A panel of judges at the Washington Station preferred the quality, without considering the nutritive value, of frozen-pack peas cooked by steaming rather than those cooked in water or in a pressure cooker.

Steaming is also recommended for frozen-pack spinach by the Massachusetts Station, after it was found that the steamed spinach had retained about twice as much vitamin C as boiled spinach.

The New York State Station found that when cooking cut or shredded cabbage a great deal of the vitamin C content is dissolved in the cooking water. The first few minutes of cooking are the hardest on the vitamin, about one-fourth of it being lost then. After that, the loss is relatively small. Cabbage that is cooked by steaming contains more vitamin C than drained, boiled cabbage. In panned cabbage, which is prepared by heating finely shredded raw cabbage with a little butter or other fat, the vitamin C retained amounts to about two-thirds of the original content, which is higher than for either steamed or boiled cabbage. The most common way of cooking cabbage—shredding, boiling in water, and then draining off the water—is the most wasteful as far as the vitamin C content is concerned. A good deal of the vitamin goes off in the water and more is destroyed by contact with the air and heat in boiling.

When apples are baked in a covered or uncovered casserole or in a pie they lose about 80 percent of their vitamin C content and if allowed to stand at room temperature for 48 hours after being removed from the oven, another 8 percent will be lost. Apples made into sauce lose about 25 percent of their vitamin C content if the unstrained sauce is made from peeled apples, and over 30 percent if unpeeled apples are used and the sauce is strained. In the applesauce made from peeled apples the greatest loss takes place during the first 4 minutes of cooking. The New York State Station, where the tests were made, found that the factors that influence the loss of vitamin C from apples are the length of the cooking period, the relatively slow rate of heat penetration with a corresponding delayed effect on the oxidizing enzymes, and the presence of air.

To supply 15 milligrams of ascorbic acid, the Washington Station has calculated that it would require about one and one-half to two average-size fresh whole Esopus (Spitzenberg) apples, two Rome

Beauty, two to two and one-half Winesap or Yellow Newtown, two to three Golden Delicious, four to five Delicious, five Richared, or six Jonathan apples.

In tests made at the New Mexico Station the vitamin B_1 content of pinto beans was retained to the greatest extent when the beans were soaked for 16 hours, parboiled for 15 minutes, and then cooked in soft water for 45 minutes at a temperature of 239° F. in a pressure cooker. The greatest loss of the vitamin occurred when the beans were soaked in water containing sodium bicarbonate and cooked by the same method, using tap water.

To improve the present methods of broiling beefsteaks the Missouri Station has an experienced panel of judges scoring steaks broiled at constant temperatures of 175° and 225° C. to an internal temperature of 58°. Mechanical determinations of tenderness are also being made. The steaks broiled at the higher temperature showed greater cooking losses, required less time but more fuel to cook, and had a greater loss in weight after removal from the oven, as well as giving a smaller percentage of edible material than did the steaks broiled at the lower temperature. The latter rated higher in palatability, with the exception of flavor and tenderness of the large muscle. After the steaks were removed from the oven the internal temperature of those cooked at the higher temperature continued to rise to about 64°, as compared to a final internal temperature of approximately 61° in the steaks broiled at the lower temperature. This continuation of the cooking process after the steaks are removed from the broiler should be taken into account when broiling steaks to the rare or medium stages.

In a comparison of club, porterhouse, and pinbone sirloin steaks, the first showed the greatest cooking losses, required the longest cooking time (almost 23 minutes per pound when cooked at the lower temperature and 20 minutes when cooked at the higher temperature) and showed the greatest rise in internal temperature after removal from the oven. The porterhouse steaks contained the largest percentage of edible meat and required 16 and 13 minutes cooking time, respectively, at the two broiler temperatures, while the pinbone sirloin steaks had the least cooking losses, required only 15 and 11 minutes cooking time, respectively, and showed the least rise in internal temperature after removal from the oven.

The Missouri Station also found that rib and loin pork chops braised without any water required only about 15 minutes cooking time, showed less cooking losses, and were more tender than when water was added. Pork chops broiled at either 150° or 175° C. had much greater cooking losses, required a much longer time to cook, and graded lower in palatability than did the pork chops braised either with or without added water. The pork chops braised without added water graded highest in the palatability factors of intensity and desirability of aroma, in texture, intensity, and desirability of flavor of lean; in tenderness of the large muscle; and in quantity and quality of juice.

While unskewered round-bone chuck roasts required almost 5 hours longer cooking time to reach the well-done stage, the Texas Station found them to be more tender even though the oven temperature was the same for the skewered and unskewered roasts.

Similar results were obtained with unskewered rib roasts which required an increased cooking time of about 2 hours over the skewered roasts. Evidently the use of metal skewers to shorten the time of cooking may be looked upon as a procedure of doubtful value where tenderness of the roast is an important factor.

New uses of agricultural products.—Scientists at various experiment stations are improving the methods of preparing and preserving fruit juices and creating new uses for these and other agricultural products. The new milk drinks that have been developed at the Illinois Station include chocolate-fudge milk, a honey-milk drink, and various fruit-milk drinks such as raspberry, grape, blackberry, pineapple, and cherry. Various cream spreads have also been developed, including fruit-flavored creams as well as cheese spreads. The development of such products is expected to expand the use of dairy products for home consumption, as well as add variety to the diet.

The Oregon Station has been developing new uses of prunes by creating new products from prune pulp and juice, and has prepared partly dried prunes for canning and dried prune halves for small packaging.

Native and imported mango varieties that lend themselves to canning, especially in the form of slices and as a juice nectar, are being investigated at the experiment station of the University of Puerto Rico. Also, an especially attractive nectar has been prepared from a red-fleshed papaya (*Carica papaya*), and the fruit has been found particularly well adapted to canning. These and other studies now in progress with citrus fruits and with grapes are of importance to the island, not alone for the possible commercial value of a large-scale canning industry but for the contribution in nutritive elements to the diet of Puerto Ricans.

The New York State Station has extended the fruit-juice studies to include rhubarb, cherry, peach, and various berry juices in addition to the common grape and apple juices. The flash-pasteurization method of preservation has been successfully applied to the home preparation of apple juice on a small scale. The procedure is simple, consisting merely of the passage of the juice, with or without clarification, and deaeration through a heated coil of tubing. The hot juice is packed in enamel-lined cans or in bottles, which are immediately closed and inverted or turned on their side for 3 minutes and then quickly cooled. This method of preservation represents a definite improvement over older methods, for the aroma, flavor, and appearance of the juice are not modified to any material degree even after storage for 1 year at room temperature.

The New York State Station has also improved the old methods of making and preserving grape juice in the home. The jars of pasteurized juice should be placed in a cool cellar for from 3 to 6 months to allow crystallization and settling out of the crude cream of tartar. Then the juice is filtered, rebottled, and repasteurized unless it is to be used immediately, or it may be kept a few days in a refrigerator without spoilage. The bottled grape juice may be used in preparing jellies by adding one of the liquid or powdered pectin preparations, according to the usual jelly-making procedure.

While a somewhat similar procedure may be followed for the preparation of cherry juice, the method has not yet been adapted for use on the average farm without special equipment.

NUTRITION

Although there is a very noticeable trend toward more research in human nutrition using human beings as subjects, the use of laboratory animals for the solution of many human-nutrition problems continues to make up a large part of the research program in this field.

The following examples of studies now in progress at a number of experiment stations give an indication of the complexity of the problems of nutrition and serve to illustrate some of the interrelationships existing among the different constituents of food. The Wisconsin Station has demonstrated that the nutritional disorder produced in rats and chicks by high egg-white intakes can be relieved or prevented by thorough cooking of the egg white or by the addition of egg yolk in amounts equaling 5 to 10 times the content of egg white in the ration. The protective factor occurs in a fairly high concentration in turkey and chick liver, to a less extent in pork, beef, and lamb kidney; pork, beef, and rabbit liver; canned trout liver; and horse adrenals, and in very small amounts in beef lung, spleen, and heart. Preliminary studies on the tissues of the rats receiving the high egg-white ration without the additional protective factor indicate that injury to the central nervous system occurs and in weanling rats a condition somewhat similar to adrenal insufficiency develops. However, the administration of a potent commercial extract of adrenal cortex does not relieve or prevent the symptoms.

The California Station has been studying the production of cataract in the eyes of rats receiving vitamin B_2-deficient diets containing either lactose or cornstarch. The results indicate that lactose favors the production in the intestine of flavine and vitamin B_6, and cornstarch either carries with it, or favors the production of, the filtrate factor. Since sucrose neither carries nor produces in the intestine any of the vitamin B-complex factors, it is recommended as the best carbohydrate for use in vitamin B_2-assay tests. It was noted, with considerable interest, that the hair of the filtrate-factor-deficient rats, particularly those on the sucrose diet, turned gray. Upon the addition of the filtrate factor the normal color returned rapidly.

Also in studies on rats, the Illinois Station has determined the relative effects of different carbohydrates and of vitamin D on mineral metabolism. The rats that were kept on the lactose ration had greater retentions of calcium, phosphorus, and magnesium than did those on the starch and sucrose diets. The greater retention on the lactose and also on cod-liver-oil rations is attributed to the decreased excretion of the minerals by way of the intestine. While the lactose, sucrose, and galactose did not exhibit any growth-promoting value superior to that of starch, the lactose did cause an acceleration in the calcification of the bone. It is of interest here to note that the Wisconsin Station has found that the content of butterfat in the milk is a determining factor in the utilization of the milk sugar by the rat.

The Wisconsin Station has been testing protein as a limiting factor in the formation of hemoglobin in nutritionally anemic rats receiving sufficient amounts of iron and copper to permit optimal response. So far as the rat is concerned, the proteins of liver, casein, egg white, and soybean meal are consistently effective in building hemoglobin, whereas corn-gluten meal, wheat gluten, gliadin, and gelatin are poorly utilized. Evidently those proteins that permit good growth will also allow optimum hemoglobin regeneration.

As an example of the many studies now in progress in a number of experiment stations in which the nutritive value of various foods is being determined by bioassays in rats, the Hawaii Station has found that the cowpea (*Vigna sinensis*) is a good source of vitamins A and B_1, and that bitter squash (*Momordica charantia*) leaves and shoots are excellent and the fruit a fair source of these vitamins. Of other vegetables commonly used by Filipinos, the sweetpotato (*Ipomoea batatas*) is an excellent source of vitamin A and a good source of vitamin B_1 and cooked shelled pigeonpea (*Cajanus cajan*) is good for both vitamins, while the horseradish tree (*Moringa oleifera*) is an excellent source. A diet high in poi is not apt to be lacking in vitamin B_1, since the content of that vitamin in taro flour is almost 1 International Unit per gram, or about 25 units per 100 calories, according to tests made at the Hawaii Station.

To the long list of discoveries whereby man's diseases have been brought under better control through tests conducted on animals may now be added the discovery made at the Wisconsin Station that the nicotinic acid amide isolated from liver is the antipellagra vitamin. When the test material was fed to dogs afflicted with the blacktongue disease it was found that an almost microscopic dose of 30 milligrams was sufficient to cure them. Work at the California Station and in other laboratories has shown that blacktongue in dogs is caused by the same dietary deficiency producing pellagra in man. Just why nicotinic acid is needed by the body is not yet definitely known, but the investigators at the Wisconsin Station advance the theory that it is present in one of the enzymes that transfer oxygen from the blood to the cells of the body, and therefore probably is essential for this purpose. It appears that the animal body cannot synthesize the vitamin from food components but must get it ready-made in the diet. The fact that liver contains the nicotinic acid amide is another point in favor of increased use of animal organs such as liver, kidney, brain, and heart, all of which are unusually rich in the vitamins that make up the B complex. The homemaker who buys only steaks and chops is missing a chance to get more nourishing foods at lower cost. Better nutrition would follow if modern folk would return to the meat-eating habits of the pioneers of this country who made use of virtually the whole carcass when they butchered an animal.

Human metabolism.—The Ohio Station, continuing studies on basal metabolism of human beings, has completed a series of tests on 11 college women, all of whom were apparently in good physical condition, although 4 were decidedly underweight in relation to age and height according to the Wood standards. For 1 week each subject weighed all the food taken and at each meal collected and weighed a sample equivalent to one-tenth the amount of the various foods selected. When the caloric value and protein content of these

samples were determined, it was found that the daily food intakes of the 11 girls ranged from 1,119 to 2,568 calories and contained from 41 to 82 grams of protein. The basal metabolism values ranged from 1,031 to 1,468 in total calories and from 31 to 37 in calories per square meter per hour.

Basal-metabolism tests were also made at the Ohio Station on 108 college women who are serving as subjects in the north-central regional cooperative project on the nutritional status of college women. For the group of 91 between the ages of 14 and 18 years, the average was 36.4 calories per square meter per hour as compared to 33.46 calories for the group of 17 girls within the age group of 17 to 22 years.

Using the same type of apparatus as was used at the Ohio Station, the Oklahoma Station made basal-metabolism tests on 84 children and 75 men. Expressed as calories per square meter of body surface per hour, the total heat production increased from 43.36 for 20 girls under 7 years of age to 52.1 for 6 girls aged from 12 to 15 years. Twelve boys under 7 years of age averaged 43.2 calories as compared to 63.45 calories for 6 boys aged from 12 to 14 years. The values obtained for the men were 41.03 calories for 27 between 17 and 19 years of age, 38.4 calories for 39 aged from 20 to 24 years, and 37.8 calories for 9 men between 25 and 30 years of age. The basal metabolism of the younger children was found to be in agreement with the northern standards of Du Bois, but fell below the normal with increasing age, the lowering being most marked with the age group of girls at puberty. The average basal metabolism of the men was 5.63 percent below the Du Bois standard.

The Nebraska Station, which is participating in the north-central regional cooperative project on the nutritional status of college women, has made balance studies on 27 college girls for periods of 5, 7, and 10 consecutive days. When the average daily intakes of protein, calcium, and phosphorus for the 5 weekdays were compared with those for Saturday and Sunday, an average difference of 22 percent was found. The difference between two consecutive 5-day periods, one of which consisted of 5 weekdays and the other 3 weekdays plus Saturday and Sunday, was nearly 15 percent. The findings suggest that a 7-day period made up of 5 weekdays plus Saturday and Sunday is necessary to secure representative food intake and subsequent metabolic picture for these college girls. A 10-day period appears to have no advantage over a 7-day period.

The Michigan Station has been studying the protein needs of children, using six preschool children receiving diets similar in all respects except for their protein content. While the protein content of the diet did not show much influence on the utilization of potassium, when the content was increased from 3 up to 4 grams per kilogram the retention of sodium and chlorine increased. During the period when they were receiving the higher protein diet all of the children showed more rapid weight gains, which are attributed to the tissue and fluid growth rather than to bone development.

Nutritional status of children.—The Maine Station, in cooperation with the State Department of Health, has been studying the food habits and nutritional status of children in selected communities in the State. They are not only collecting valuable data on the chil-

dren, but are finding out what improvement may be brought about in their health and nutritive condition as the result of health education in the schools and instruction of the mothers through various agencies. In a group of 250 children, bone defects from early rickets were frequently found, but there was very little evidence of vitamin A deficiency as determined by biophotometer tests. About one child in eight was 10 percent or more underweight in the fall examinations and about one in seven when the physical examinations were made the following spring. Except for an increased consumption of milk, the diets of the children had not improved markedly since the previous year.

The investigations of the South Carolina and Mississippi Stations, noted later in this report, reveal that many of the farm families studied were existing on diets low in calcium, iron, and several of the vitamins. Soils in some parts of the Southern States are known to be so deficient in iron that hogs raised on the forage grown there fail to grow and mature well. On the basis of such findings it has been suggested that the deficient soil is related to the occurrence of certain mild anemias so prevalent among the women of the South. The possibility of such a relationship is under investigation at the Florida Station. Hemoglobin values are being determined for groups of school children, and at the same time the predominant soil types for each district where the children live are being classified and mineral analyses made of the vegetables grown on these soils. In addition, dietary studies of representative families are being made. The evidence already accumulated indicates that the children whose food is grown on better soil have higher hemoglobin values. It would appear that the incidence of anemia among these Florida children is definitely related to the mineral, and particularly the iron content of the soil.

EQUIPMENT

It has long been realized that for nonacid foods the pressure-cooker method of canning is the safest. However, a recent survey in Nebraska indicated that considerable spoilage was occurring in foods canned by this method, and one of the causes seemed to be the inaccuracy of the pressure gages. As a result, a study was made by the Nebraska Station to determine the dependability of the pressure gage, the proper functioning of the safety valve, the methods of sealing the lid to the cooker, the evacuation of air from the cooker, and the use of a thermometer as the temperature indicator. From tests made on 12 new gages the possibility of constructing gages accurate within ± 0.5 pound per square inch was demonstrated. Using that figure as the limit of correct calibration, only 11 of 40 gages tested were found to be accurate under a pressure of 5 pounds and 7 under a pressure of 15 pounds. The safety valve in 6 of 11 cookers tested blew off satisfactorily at pressures between approximately 18 and 25 pounds, while the other 5 began to leak at pressures below the release pressures. In 8 of 10 new cookers leaks appeared around the safety valve at pressures of 18 and 20 pounds. The type of pressure cooker that has the cover clamped on by a band with one bolt was found to be the easiest to seal.

In choosing a pressure cooker the most important points to consider are the size and shape; the material from which it is made; the method of sealing and clamping; the type of pressure gage, safety valve, and petcock; and the possible use of a thermometer fitted into the cover. When the pressure cooker is used for canning nonacid foods the Nebraska Station recommends that the gage pressure be increased one-half pound per square inch for each additional 1,000 feet at altitudes above 1,000 feet. The temperatures indicated on the pressure gage should not be used as an indication of the processing temperature, since these temperatures are correct only for processing at sea level with an accurate gage. While the thermometer cannot replace the pressure gage the cooker may be equipped with a thermometer as well as a gage if it is desired to process in terms of temperature readings. The wise buyer of a new pressure cooker will have the pressure gage checked before purchasing the cooker and rechecked at the beginning of each canning season. In Nebraska the experiment station laboratory offers this service free to the citizens of the State. Some manufacturers of pressure cookers also advertise such service.

ECONOMICS OF THE FAMILY

During the past 10 years the Illinois Station has summarized the home account books of 1,044 families. Many of the families have kept continuous records since the year they started their first record. The farm-family home-account survey for 1937 was prepared from the home-account records received from 280 farm families living in 49 different counties located in all parts of the State.

The money value of living plus savings for these families was $2,252, which is 7 percent higher than the $2,113 for 240 farm families keeping home accounts in 1936. More cash was available for living, life-insurance payments, and the payment of principal and investments other than farm business in 1937 than in any year since 1929. When the amount of savings was deducted, the money value of living was $1,826, of which $618 was the value of the goods furnished by the farm for family use, and the remainder was met by cash expenditures. The value of the farm-furnished food was a little over one-fifth of the money value of living of the whole group.

Purchased food continues to be the most important item in the family's living. Not only was the money value of the food consumed over one-third of the entire money value, but on every income level the expenditure for food was the largest single cash outlay. Automobile purchase, maintenance, and operation ranked second, operating expenses third, and clothing expenditures fourth for the whole group on the average.

In recent years the Illinois Station has noticed a steadily growing interest in home modernization among the home-account keepers. Two of the goals most frequently mentioned by the farm homemakers have been home furnishings and equipment, and home improvements. Defining a modern home as one with a central heating plant, a lighting system, and running water under pressure, nearly one-third of the families lived in completely modern homes. Trends toward more comfortable living are evidenced by electrification and other im-

provements of farm homes and by purchases of household equipment to lighten the daily tasks. Such improvement in the way of living is the result of careful financial management on the part of the account-keeping families.

In order to obtain accurate information on relatively new houses, in which a contribution of home labor and native materials has been made, the Arkansas Station obtained records in 1937 on a group of 214 farmhouses, well distributed as to location, size, structural material, cash cost, and the annual income of the owners. The families studied had an average annual income of $785 and an average cash expenditure for the house of $740, with about one-third of the group spending less than $250. About 70 percent of the houses were built without plans other than those prepared by the owner, 20 percent used some type of planning service, such as bulletins, booklets, periodicals, or plans furnished by the State College of Agriculture, and 10 percent obtained planning assistance from individuals. As might be expected, the planned houses averaged higher in cost, value, and convenience than the unplanned houses.

The four-room house size was the most common, and three-fourths of the houses had four, five, or six rooms. About 16 percent were classified as "crowded," that is, they contained less than one room per family member. In this group the family size was above average, a greater proportion of the value was contributed, and the annual income and expenditure for housing were below the general average. As the cash expenditures increased, the proportion of home labor used in the building decreased. The greatest proportions of home labor were contributed by families in the income groups under $500. On the basis of cubic-foot unit costs, the average calculated value was $1,575 per house. The cash cost was 44.4 percent of the house value, and the home contribution amounted to 55.6 percent. It is obvious that the varied conditions existing in different communities complicate the problem of farm housing, and no uniform basis of size, quality of construction, or cost can be established that will meet the housing needs of any considerable number of families.

The average cost of medical care for the Illinois farm families keeping home accounts during the past 9 years has ranged from $41 to $86. In the 1937 accounts of the 280 families medical care was the eighth item on the cash expenditures records and averaged $72.

Further information on the costs of sickness and medical care was obtained in a study made by the Arkansas Station. In a typical community of the Ozark section, 322 families were interviewed as to the state of their health, the costs and type of medical service utilized, and their indebtedness for medical care. Information was also obtained from persons professionally connected with health services and from the records of the State health department. The families were largely farm owners, with a few large landowners and some townspeople who were engaged in both farming and business. The community, with a total population of 1,292 persons, had one resident doctor and four practical nurses but no dentist and no hospital. The entire county had only three registered nurses. About 25 percent of the families had total incomes under $250 and only 1 percent had total incomes over $3,000 a year.

The reports from the heads of the families showed that 73 percent of the people were in good health, 10 percent in fair, and 17 percent in poor health. The most illnesses occurred in January and February and the least in October and November, with influenza, colds, stomach trouble, rheumatism, and heart trouble being the most common ailments.

The average yearly expenditure for medical services was $26.67 per family, or $6.65 per person. Of that amount the services of a physician took 44.8 percent; unprescribed medicine, 19.9; prescribed medicine, 17.6; hospital services, 5.5; dental care, 5.1; practical nurses, 4.1; chiropractic services, 1.2; registered nurses, 0.8; midwives, 0.5; and ambulances, 0.2 percent. Over half of the families had used the services of a physician, about one-seventh had visited a dentist, one-eighth had practical nursing services, and about one-twentieth had been in a hospital during 1936.

The highest-income families enjoyed better health and had fewer sicknesses, and, in addition to a higher expenditure for medical care, they also spent more for prescribed medicines and used less home and herb remedies. Although the low-income families spent fewer dollars on medical care it represented a much larger share of their incomes, and over 40 percent were in debt for medical services as compared with about 15 percent of the families in the higher-income groups. Two serious obstacles to adequate medical care for the low-income families were the lack of transportation and the poor means of communication.

With clothing expenditures of farm families ranking among the "big four" of living expenses, along with food, household operation, and the family use of the automobile, the studies at the Wisconsin and Missouri Stations on expenditures for textile fabrics and clothing are particularly interesting.

The character and extent of home clothing construction and the costs involved in home manufacture were obtained in a study conducted by the Wisconsin Station on the clothing expenditures of about 900 persons in some 200 rural and village families living in central Wisconsin. The value of the living which these families were able to secure ranged from about $500 to $1,300. While the clothing expenditure for the typical family of four persons was about $85, the average clothing value of $102 is really a more significant figure, since it includes, in addition to actual expenditures, the value added by home construction and the clothing gifts received by the family. As might be expected, the number of garments made at home for men and boys was so small that it added almost nothing to the average value of the clothing acquired during the year. Nearly two-thirds of the women and girls, however, had some clothing constructed at home.

The costs of a number of home-made garments for women and children were compared with the prices of comparable commercial articles. The amount paid for the materials, together with the calculated cost of the equipment used, including repairs, depreciation, and loss of interest on investment, was taken as the cost of the garments made at home. No consideration was given to the home labor costs. The costs of the ready-made garments were the average prices

advertised by various stores and mail-order houses where the families did their buying. The probable differences in style, finish, and durability between the two types of garments were not considered.

Cotton dresses made at home represent a saving of almost 65 percent, and wool or part-wool dresses of 61 percent. For cotton slips and pajamas or nightgowns made at home the savings were about 47 and 50 percent, respectively. The saving in home-made undergarments amounted to only 30 percent, and in aprons to 40 percent. The amount of saving appears to depend largely on the type of garment, the amount of hand work which has to be paid for in the ready-made garment, and the readiness with which mass-production methods may be applied in commercial construction. The saving also appears to vary to some extent with the age of the person for whom the garment is made, being greatest for the older girls and women and decreasing with the age of the younger family members, so far as outer garments are concerned.

The Wisconsin Station investigators were interested to find that in families of seven or more persons, the tendency to make and make over clothing in the home was much greater than in the smaller families. The opportunity of purchasing relatively cheap ready-made garments may be the reason that more home sewing was not being done by the families. Other factors probably are the absence of sewing machines in many homes, and the lack of skill in sewing, as well as the pressure of other household duties.

The replies made by 40 homemakers to a questionnaire sent out by the Missouri Station give an indication of the demand for textile fabrics for various purposes. Most of the homemakers were buying cotton materials for curtains, preferably a marquisette. Wool blankets were much preferred to part wool or cotton. Durability and a soft texture were considered the most important qualities to look for in cotton sheeting, while durability, softness, absorbent capacity, and ease of laundering were considered in purchases of ready-made towels of cotton turkish toweling. For dish towels the greatest demand was for cotton ones made at home from flour or sugar sacks. The greatest demand in dress slips was for ready-made pure dye silk ones costing less than $2 apiece, although many of the women liked rayon slips and some favored cotton ones if made of preshrunk materials. The majority of the women preferred ready-made house dresses costing less than $2. If they made their own house dresses they wanted preshrunk, fast-color cotton fabrics costing less than 30 cents a yard. Afternoon dresses of pure dye and washable silks priced at less than $20 were very popular and there was a great demand for ready-made cotton afternoon dresses. Among the complaints registered by the participating consumers were the difficulty in distinguishing between silk and rayon fabrics in the absence of adequate labeling, and the poor seam construction that can be found in ready-made dresses at various price levels.

The major demand on the cash income of the farm family is the expenditure for food, even with a large home-production program. During the past few years there has been a definite trend toward better planning to meet family food needs. In many farm homes the family now estimates the quantities of different foods needed for

satisfactory diets and then decides what and how much might well be produced at home and what and how much purchased.

The South Carolina Station has kept detailed weekly records of the foods eaten by groups of farm families living on the lower Coastal Plain and in the upland sections. The white and Negro families living mostly on tobacco farms in the lowland section raise less food for home use and have poorer diets than do the upland farm families, which are mostly white, independent, small farmers raising much of their own wheat and corn and having gardens and cows. Their meals are based on milk and cereals, and include typical southern foods, such as sweetpotatoes, greens, corn meal, and sorgo sirup. Because the upland farmers produce a variety of foods their diets in general are good, even when their cash incomes are low. The lowland farmers buy flour instead of growing their own grain, and have very little milk but more lean meat. The investigator is of the opinion that most of the low-income families on poor land could have adequate diets if they would produce more of their own foods, especially the "protective" foods like milk, green and yellow vegetables, fruits, and eggs.

At the Mississippi Station dietary records were kept of white and Negro farm families representing both landowners and tenants, half of them living on good soil and half on poor. These records show that the white families living on good soil have better diets than do those living on poor soil. The former are practically all landowners, and usually have a vegetable garden and an orchard and their own cow, chickens, and pigs. They make their own corn meal and table sirup, preserve their garden products, and put up wild berries for winter. Naturally they spend less money for food than do the white families living on poor land. The latter are mainly tenant farmers who produce much less of their own food, and through lack of money are unable to buy enough of the "protective" foods. Probably because of the uncertainty of their tenancy, few of them are interested in planting fruit trees or a garden and they have fewer chickens and pigs. Because their cows are inferior and have poor pasturage, their milk supply is often low. Because their pigs are inferior their meat is scant—too high in fat, too low in lean.

The Negro families living on poor land are more likely to be landowners and generally have better diets than do the Negro families living on good land. The latter are usually tenants on farms devoted to cash crops such as cotton and tobacco. For this reason, and also because the owners of the good land are rarely interested in allowing the tenant to use even a small part of it for a garden, orchard, or pasture, such families cannot produce much of their own food, and since they have little with which to buy food their diets are very poor. The groups of investigators at both the Mississippi and South Carolina Stations have reached the same conclusion, namely, that it is not so much the land as the way the land is used that influences the diets of farm families.

RURAL ECONOMICS AND SOCIOLOGY

CONTENTS

The stations have continued programs of investigation of rural economic problems with a view to obtaining data upon which to base recommendations and outline plans for the improvement of rural economic conditions. While the individual stations have given particular attention to the problems in their own States, many of the investigations were so designed that the data could be coordinated with the findings of other stations to form a part of regional or Nation-wide studies. An increasing proportion of the work was done in cooperation with the Bureau of Agricultural Economics, the Soil Conservation Service, the Forest Service, and other bureaus and agencies of the Department of Agriculture and with other Federal agencies such as the Works Progress Administration, Farm Credit Administration, and the Department of the Interior. As in the past, the major part of the work has been in the fields of farm management, marketing, and agricultural adjustments. Taxation, tenancy, land-tenure, prices, credit, land-classification, and type-of-farming studies have also received considerable attention.

The number of active projects in rural sociology on Federal funds increased from 64 during the previous year to 68 during 1938. The projects included 17 on rural population, 7 on standards of living, 5 on social psychology, 1 on rural health, 6 on rural welfare, 2 on rural-urban relationships, and 30 on social groups, including the rural family, the rural community, regional studies, and organization.

RURAL ECONOMICS

LAND CLASSIFICATION AND USE

Land classification.—Land-classification studies were in progress at a number of the stations as the basis for recommendations as to agricultural adjustments, resettlement, use of lands, taxation, etc. The New York (Cornell) Station continued its studies by counties and published several reports showing the use of lands of different classes, ownership, size of farms, condition of buildings, labor incomes, the value of lands, and the development of roads, rural electrification, etc., in different counties.

The Idaho Station summarized by counties basic data for land classification, such as crops and annual production, types, uses, ownership, assessed valuations of lands, tax delinquency, etc., gathered in cooperation with the Department of Agriculture (F.S.), Works Progress Administration, Idaho Planning Board, and other agencies.

In a study of the lands of West Virginia, the West Virginia Station found approximately 1.5 percent of the area is superior crop-

land, 2.3 good cropland, 3.4 average cropland, 9.1 below-average crop or good pasture land, 30.7 inferior crop or average pasture land, 20.5 submarginal land, 31.8 forest land, and 0.7 percent urban or industrial land. Maps were prepared showing the areas in the different land classes and with different slopes and soils.

Use of lands.—In another study of the New York (Cornell) Station of agricultural production in New York from 1866 to 1937, it was found that from 1880 to 1935 the number of farms decreased 27 percent and the area in farms 18 percent. In spite of the decrease of 4,200,000 acres, the total agricultural production had increased 20 percent, due to the use of fertilizers and lime, improved varieties of crops, better control of diseases and insects, more legumes, higher-producing cows and hens, and better feeding and disease control of livestock. Production per acre of crops, except fruits, increased 21 percent from 1899 to 1934. Milk production per cow more than doubled from 1864 to 1934. Agricultural production per man nearly doubled in 60 years.

A study of the farm businesses from 1929 to 1935 on 141 Ohio farms by the Ohio Station showed that there was no tendency to make major changes in farm organization, except to increase or decrease the scale of operations. As prices of the products declined, the total acreage in the farms and the acreage in crops tended to increase. From 1929 to the end of 1932 net cash income decreased 50.1 percent, cash receipts 51.7, and cash expenses 52.9 percent. In 1935 the decline in net cash income from 1929 was 12.8 percent, in cash receipts 19.3, and in cash expenses 24.2 percent. Curtailments in the expenditures by 1932 resulted in only two-thirds of the previous quantity of feed being purchased, only slightly more than one-half of the total tonnage of fertilizer and lime being used, and one-half the number of breeding and feeding stock, and one-third of the number of farm implements being purchased. The amount of hired labor remained fairly constant, but due to the use of more family labor the number of men employed per farm increased from 1.5 to 1.9. The station in another study made in cooperation with the Department of Agriculture (F.S.A. and B.A.E.) found that the number of farms in six townships studied increased 5.6 percent from 1930 to 1936. The new farms were predominantly part-time farms and the increase was greatest in the poor-land-river-commerce area and least in the good farming area. The new farms in the poorer agricultural areas materially increased relief costs and in no case were they sufficiently numerous to assume a significant portion of the township or county tax basis.

Type-of-farming areas.—Detailed reports of studies, made in cooperation with the Department of Agriculture (B.A.E.), were published by the Missouri, Texas, and Wyoming Stations. Similar studies in other States were in progress or had been completed in previous years.

COST OF PRODUCTION

Costs in Illinois.—Twenty-five years of farm cost-of-production studies made by the Illinois Station showed that the amount of human labor required to produce a given quantity of Corn Belt crops is approximately 50 percent today of what it was 25 years

ago, that the unit cost of production of most staple crops has been reduced but little, and that the greater use of machinery and mechanical power has increased the proportion of cost that must be paid in cash. On new crops generally adopted during the period—alfalfa, sweetclover, and soybeans—there was a gradual increase in the yield and a lowering of cost as improved cultural practices and new and improved varieties were developed. An analysis of the accounts and records of members of the Illinois Farm Bureau-Farm Management Service in the north-central counties of the State brought out the fact that the use of the better practices has increased the average yield of corn 31.4 bushels per acre, of which 11.7 was accounted for by soil-treatment practices, 9.9 by good cultivation on well-treated soils, and 9.8 bushels by practices having to do with kind, selection, storage, and preparation of seed. Superior practices with oats resulted in an average gain of 39.7 bushels per acre on well-treated land, 25.2 on fairly well-treated land, and 17.5 bushels on poorly treated land. Farmers following the better practices in producing, feeding, and marketing hogs had an average return of $33 per $100 worth of feed fed over other farmers. When pullets were hatched in February or March and fed a laying mash throughout the year, poultry returned an average of $119 more per $100 invested in the flock than when the pullets were hatched in May or June and fed a laying mash during only part of the year, if at all. Dairy herds with 71.1 percent of all cows milked and an average production of 8,815 pounds of milk per cow returned $61 more per $100 worth of feed fed than did herds where only 43.5 percent of the cows were milked and the average production per cow was only 6,107 pounds of milk.

Filberts.—The Oregon Station, in a study during the period 1928–34, found the cost per acre to bring a new filbert orchard through the first 5 years to be $164 for land and $153 for growing costs. Of the latter cost nearly $59 was cash expenditure. The average cost of producing filberts was $52.37 per acre, or 13.2 cents per pound, in 1932, and $59.29 per acre, or 7½ cents per pound, in 1933.

Potatoes.—A study in Aroostook County by the Maine Station showed that on potato farms where at least one of the three factors, size of business, yield per acre, and labor efficiency, was above the average, the returns were 10 to 21 percent above the average. Where two of the factors were above the average, the net returns were 14 to 36 percent above the average. Where all three factors were above, the net returns were 97 to 175 percent above the average. Average growing and harvesting costs decreased from $1.61 per barrel with yields of 73 barrels per acre to 92 cents where yields averaged 150 barrels per acre. The average cost on farms averaging 15 acres of potatoes was $145 per acre, as compared with $121 where there were 88 acres of potatoes.

Broilers in Maryland.—A study of the broiler industry in Maryland for 2 years ended June 30, 1936, and covering a production of over 1,960,000 birds brought out the facts that the average investment per bird was 16.4 cents, the average income 54.5 cents, and the average net profit 5.67 cents per bird. Returns for birds varied from a net loss of 81 cents to a net profit of 33 cents in 1934–35, and from a net loss of 44 cents to a net profit of 40 cents in 1935–36.

Gross income and cost per bird averaged 63.8 and 45.5 cents on the 25 most profitable farms and 48.6 and 56.8 cents on the 25 least profitable farms. The most profitable farms had an average investment of 14.7 cents per bird and the least profitable farms 21.4 cents. The most profitable size of enterprise was from 5,000 to 15,000 birds per farm. Profits increased as the weight of the broilers increased above 2½ pounds, the most profitable weight being 3 pounds or over. It was most profitable to raise one or two lots of broilers per year. Profits decreased as the percentage of mortality increased over 10 percent and a loss was sustained when it exceeded 25 percent. Sales to local buyers and truckers were the most profitable method of marketing.

Responses of milk production to prices.—The New York (Cornell) Station found that in New York as a whole, the long-time response in production to changes in the grain-milk price ratio lagged 2 years and the short-time response lagged usually 1 to 4 months. The price of grain seemed to have a greater short-time effect than the price of milk. Estimates of monthly production based on the long-time and short-time price-production relationships were within 5 percent of the actual production most of the time.

LABOR INCOME

Dairy farms.—The New York (Cornell) Station in a study of 100 grade A milk farms in the Tully-Homer district of New York for the year ended February 28, 1937, found the average labor income (the amount the operator received for his labor in addition to use of dwelling, products used, and other privileges) per farm to be $1,049 and the value of operator's privileges $470. Various factors increased labor income as follows: One additional cow, $42; 100 pounds additional milk per cow, $42; each additional point in crop index above the 10-year average for the State, $15; 1-percent increase in receipts from crops sold, $51; and 1 ton more milk produced per man employed, $61. Farms with none of the factors as good or better than the average for all farms had an average labor income of $35. those with one as good as or better than the average, $98; those with two, $794; those with three, $1,360; those with four, $3,387; while those with all factors as good or better had an average labor income of $4,202.

A study of 60 dairy farms in Puerto Rico in 1935–36 made by the experiment station of the University of Puerto Rico showed the following relationship to labor income: One cuerda (0.9712 acre) increase in size of farm increased the labor income $9; one more cow per farm increased it $30; and an increase of $1 in the value of milk sold per cow resulted in an increase of $29; and an increase of 100 quarts of milk per cow in an increase of $198.

Poultry farms.—A study of commercial poultry farms in New York covering the years 1926 and 1929–33, by the New York (Cornell) Station showed the effects of different factors in increasing labor income to be: decrease of 1 cent per dozen in cost of producing eggs, $50; $1,000 increase in farm capital, $41; an increase of 100 layers, $95; an increase of 1,000 dozen eggs per farm, $85, and per man employed $154; 12 eggs more per hen per year, $176; 1-percent increase

in the percentage of eggs laid October to December, inclusive, $51; 10 cents increase in value of eggs per $1 of feed fed, $148; 10-percent increase in income from pullets and chicks sold, $378; a decrease of 1 year in the time required for receipts to equal capital invested, $771; $100 increase in gross income per man, $69; and a decrease of 1 percent in mortality in the number of layers at the beginning of the year, $17.

Virginia farms.—The Virginia Station in a study of 127 farms in Appomattox County, Va., for 1935 found the average labor income to be $131. Increase in size of business increased farm income but had little relation to labor income, the effect of size of business not being sufficient to offset the large and rapidly increasing interest allowance on capital invested. Higher rates of production were accompanied by increase in labor income and increases in days of productive work per man gave consistent increases in labor income. The study indicated that a good balance of business in the area would result from a farm organization providing for 15 to 25 percent of the total receipts from livestock, 35 to 45 percent from tobacco, and 10 to 20 percent from other crops such as small grains, hay seed, and in a few cases vegetables.

South Carolina farms.—A study of 52 farms in Saluda County, S. C., by the South Carolina Station in cooperation with the Department of Agriculture (B.A.E.) showed the average labor income to be $22, varying from an average of $548 on the 13 highest to −$388 on the 13 lowest farms. The labor income increased with acreage of cultivated land per farm up to $293 for the group having 76 to 150 acres as compared with −$151 for those with 30 acres or less and with the percentage of cultivated land in cash crops, being $693 for those having 40 percent or more in such crops, as compared with −$90 for those with 19 percent or less.

MARKETING

Consumption of dairy products.—The average per-capita consumption of fresh milk in 1935–36 in Burlington, Vt., was found by the Vermont Station to be 168 quarts, ranging from 96.6 for families on relief to 202.8 quarts for those with weekly incomes averaging over $50, and from 127.4 for Italian families to 193.1 quarts for Hebrew families. The average milk equivalent for fresh milk, canned milk, cream, butter, and cheese was 1,189 pounds, ranging from 697 for families on relief to 1,521 pounds for families with average weekly incomes over $50, and from 843 for Italian families to 1,376 pounds for English-Scotch families. A study by the Kentucky Station of milk marketing in Lexington, Ky., showed the average per-capita consumption of milk, cream, and buttermilk to be 0.56 pint per day. The Maryland Station found from schedules returned by mail in 1937 from 2,375 Baltimore families the average daily per-capita consumption of milk to be approximately three-fourths of a pint. Of the families, 24.4 percent reported an increase over the preceding year and 19.5 percent a decrease.

Cost of distributing milk in New York City.—From cost records for October 1933 for 11 retail sales branches with 775 retail or mixed routes and 33 wholesale routes, and from 7 wholesale distribution

branches with 111 routes, the New York (Cornell) Station found that the average daily volume delivered per retail route was 329 quarts and the average total cost of delivery 4.89 cents per quart. Delivery and selling costs on the wholesale routes ranged from 1.99 cents to 3.65 cents per quart, averaging 3.1 cents. It was suggested that retail costs might be reduced by a differential in price based on size of purchases, discontinuance of doorstep deliveries in sections where most of the milk is delivered through stores, deliveries only on alternate days, use of more helpers in the more intensive sales areas, and restriction of the number of dealers. For wholesale deliveries it was suggested that discounts be given for volume purchases, the number of dealers be restricted, the furnishing of free ice to consumers be discontinued, paper bottles be used, and that there be a stricter control of credit.

Trucking charges on milk.—The New Hampshire Station, in a study of commercial trucking of milk, found that trucking charges did not vary consistently with distance, volume carried, or other factors generally regarded as influencing costs of truck operations. On routes collecting the same amount from about the same number of farms and covering about the same distance, the average charges ranged from 15 cents to 30 cents per 100 pounds of milk. It is estimated that if one route out of five reduced its average rate 5 cents per 100 pounds about $12,000 per year would be saved to milk producers. The Connecticut (Storrs) Station, in a similar study of 237 routes, found that on routes of similar length, road conditions, volume of milk transported daily, and services rendered by truck drivers, variations in charges of 10 cents per 100 pounds were common, and 15 cents fairly frequent. On routes of similar length and volume of milk per day rates tended to be lower on the routes including the largest number of miles of unpaved roads, and on the routes where the most services were rendered. On routes where over 1,000 pounds of milk was transported per day, the rates of distributor-truckers averaged 29.96 cents per 100 pounds and those of independent truckers 23.27 cents. On 75 percent of the milk handled by independent truckers, the charges were 25 cents or less, while on over 74 percent of the milk delivered by distributor-truckers the charges were 27.5 cents or more per hundredweight.

Cooperative creameries.—The Minnesota Station, in a study of 175 cooperative creameries manufacturing from 45,000 to nearly 1,670,000 pounds of butter annually, found that the total cost of manufacturing a pound of butter in 1934 ranged from 1.09 to 4.796 cents, averaging 3.554 for creameries manufacturing less than 125,000 pounds, 2.619 for those manufacturing 375,000 to 499,999 pounds, and 2.13 cents for those manufacturing 625,000 pounds or more. The approximate average returns available per pound of butterfat were 25.35 cents in the first group, 27.415 cents in the second group, and 28.448 cents in the third group. The patronage and volume of business of most of the creameries was limited by competing butterfat buyers in their territory, there being commonly from three to seven buyers in a 10-mile radius. Side-line sales including market milk and cream sales constituted 8.8 percent of the total sales of the creameries. The Station states:

It may be concluded that the cooperative creamery has been an important factor in the improvement of agriculture in Minnesota. The cooperative has improved the returns of the butterfat producer by manufacturing a high-quality product which has commanded a premium on the market. At the same time the cooperative creamery has been a means of combating inefficiency in the manufacture of butter, thereby reducing the costs of operation and the margins retained on each pound of butterfat handled. * * * Although cooperative creameries in general have achieved the purposes for which they were originally organized, there are indications that they are not adjusting their organizations and operations as readily as they should to important developments which the industry has experienced in recent years. * * * Improvements in transportation facilities have made it possible for a local creamery to serve a larger area than when they were first established. There is need for a consolidation of creameries for greater efficiency in operation in order that the net returns to the patrons may be increased. * * *

Cooperative elevators.—A study of cooperative elevators during 1925–35 by the Michigan Station brought out the fact that during that period more than one-fifth of the elevators operated in 1925 went out of business. The trade areas served in 1935 averaged less than one-half the size of those served in 1925 and the average number of patrons per elevator was considerably greater in 1935 than in 1925, but the nonmember patrons exceeded members by 105 percent in 1935 as compared with an excess of 35 percent in 1925. The farm-supplies business, which grew up largely during the period, in 1935 showed sales in excess of that of products. The surviving elevators were found to have finished the period in better shape as to physical resources than in 1925, there being a total property gain of over $1,308,000. Although the total loss of membership in 90 of 98 elevators from 1925 to 1935 was only 641, over 75 percent of the individual elevators had less members in 1935. Of the members in 1935, 14,572 were producers, 1,598 nonproducers, and 422 nonresidents. Of the 97 elevators reporting, 70 paid average annual dividends on stock during the years 1930–35 of 5 to 25 percent. While patronage dividends were provided for by 61 of the elevators, such dividends were paid by only 27.

The Nebraska Station in a study covering the period 1922–35 and including about 20 percent of the farmers' elevators in the State, found the average net income ranged from $143 in 1932 to $3,354 in 1928, averaging $1,553, or $9.70 per $100 of capital stock. The percentage of the elevators showing gains varied from 30 to 89 in the 2 years, averaging 69 percent for the period. The average cost per bushel of handling grain in 1928, a year of high prices, was 7 cents in the elevators handling less than 100,000 bushels, and 2.8 for those handling over that amount. In 1932, a year of low prices, it was 6.2 cents for those handling less than 100,000 bushels, 3.5 for those handling 100,000 to 199,000, 2.5 for those handling 200,000 to 299,000, and 1.9 for those handling 300,000 bushels or more. The percentage of gross income from grain averaged 79.1, varying from approximately 73 to 87.5 in different years.

Potatoes.—A study by the Michigan Station showed that about 85 percent of the potatoes used for food in that State were grown in the State and about one-fifth of the State's production, or one-third of the volume sold by farmers were marketed in other States. Consumers in Detroit were found to prefer medium size (2½-inch diameter) oval-shaped potatoes. About two-thirds of the customers

expressed a preference for white skins, and about one-third for russet varieties. About three-fourths of the consumers were willing to pay a somewhat higher price for the characteristics which they preferred. Hotels and restaurants preferred a larger potato (3- to 3¾-inch diameter), but had less marked preference as to shape. The Station states:

Although the best Michigan potatoes are probably equal to the best from other late crop states, a comparison of 50 test samples from each of the states of Michigan, Maine, and Idaho indicates that the Michigan potatoes sold in Detroit are not as satisfactory to consumers as those from the other two states. Differences in the kind and amount of defects present were more important than differences in size. Consumers paid an average of 44 cents per peck for the Michigan samples, 52 cents for the ones from Maine, and 66 cents for the Idaho potatoes. The cost per pound of usable potatoes was 3.08 cents for Michigan, 3.58 for Maine, and 4.55 cents for those from Idaho.

Eggs.—A study of the relation of quality to retail prices of eggs in Rhode Island was made by the Rhode Island Station based on data obtained in 1928–29 and 1934–35. Retail prices of nearby eggs of the same score and same air-cell depth averaged 12 to 21 percent and 15 to 21 percent higher in the respective years than did the prices for western eggs of the same quality and with air cells of the same depth. Eastern eggs scoring 90 or better by the station's system of scoring, sold for 17 percent more than those scoring 50 to 59.9, while western eggs scoring 80 to 89.9 sold for 11.5 percent more than those scoring 40 to 49.9. The average scores were: Eastern eggs, 81; western eggs, 65; and storage eggs, 61. The price for storage eggs averaged 34 percent less than that for eastern eggs and 17 percent less than that for western eggs. The term "fresh" as defined by the Rhode Island law was used for nearly 54 percent of both eastern and western eggs. The average prices for the eggs so marked were 3 percent higher in the case of eastern eggs and 0.5 percent higher in the case of western eggs not so marked, but the average score for the eggs so marked was two-fifths of a point lower in the case of eastern eggs and 2.2 points lower in the case of western eggs than those sold not so marked. The price of large eastern eggs averaged 3.7 percent higher than that for medium eggs and 28.3 percent higher than that for small or pullet eggs. The price of 24-ounce eggs averaged 16.1 percent higher for eastern eggs and 13 percent higher for western eggs than the price of 21-ounce eggs. Shell color did not affect prices appreciably. Eggs in cartons brought about 2½ percent higher prices than uncartoned eggs.

The Illinois Station, in a study of egg shipments from nine counties in the southeastern part of the State to New York City during June and July 1936, found practically no difference in quality of eggs going by rail and by truck when the time in transit was the same or those shipped in iced and noniced cars where the eggs had been precooled and shipments moved to New York City in 3 days. Storage in New York City for periods of 138 and 119 days caused a deterioration of about one grade in quality. A limited flock range and quick cooling of eggs immediately after laying were found to be important factors in the production of eggs of good quality.

The Connecticut (Storrs) Station, in a study of egg auctions at Hartford and Hamden in July and October 1935 and January and April 1936, found that each additional pound in gross weight of a

30-dozen case brought an average increase of from 14 to 36.8 cents at Hartford, and from 13.9 to 43.2 at Hamden. Special grade eggs brought 18.6 to 38.7 cents more per case at Hartford, and 4.5 to 58.5 cents more at Hamden than did extra grade eggs, which in turn brought 10.5 to 22.2 cents, and 43.5 cents to $1.275 more than the Connecticut-gathered grade. Shell color had only a slight effect on prices at either market.

A study of the New Hampshire Egg Auction by the New Hampshire Station showed that one-fourth of the shippers in 1935–36 sold 100 cases or more through the auction, the total volume being about two-thirds of that handled by the auction. About 60 percent of the buyers attending the semiweekly auctions were peddlers who bought about 40 percent of the eggs sold. The auction prices for New Hampshire Special Grade Large Brown eggs exceeded Boston wholesale quotations on the Nearby Special grade in about 80 percent of the sales. Special Grade Large Brown eggs brought an average premium of about 2 cents per dozen over the Extras. The average margin in retail stores in 1935–36 was about 6.2 cents per dozen.

Strawberries.—In a study made by the Connecticut (Storrs) Station of the New Haven strawberry auction in 1933 and the Manchester auction in 1935, it was found that 36 percent of the price variations at New Haven and 30 percent of those at Manchester were explained by average size of berries, 10 and 5 percent, respectively, by condition of berries, 2½ and 1½ percent by uniformity in size of berries, and 1 percent at each auction by color, and 0 and about 2 percent by size of the lot sold. The average difference in price per crate between ⅞-inch and 1½-inch berries was 98 cents in the New Haven and 57 cents in the Manchester auction. Crates with only 1 percent of the berries in poor condition brought 37 and 28 cents more, respectively, on the two markets than those with 15 percent of the berries in poor condition. When the percentage of berries one-fourth inch or more smaller than the average rose to 9 percent, the average price per crate fell 26 cents at New Haven and 23 cents at Manchester.

Apples.—The Delaware Station in a study of retail marketing of apples by a Philadelphia chain-store warehouse found that prices change on an average of about every week and a half, the usual changes being between 30 and 40 cents a bushel, and that the spread between local wholesale and retail prices was approximately 40 percent of the retail prices of most varieties. Stores catering to low-income people sold from one-half to three-quarters as many bushels of oranges as apples while those in wealthy sections sold two and one-half times as many bushels of oranges. Sales of peaches during July and August were double those of apples and the peak month sales for peaches exceeded the peak month sale for apples.

Florida citrus fruit.—The Florida Station, in a study covering the three seasons 1930–31 to 1932–33, inclusive, found the average costs per box for freight, selling, and other costs exclusive of preservation, for rail shipments to the markets studied were: New York, $1; Chicago, $1.07; Detroit, $1.08; Cincinnati, $0.94; and Pittsburgh, $1.03. Rail and water shipments to New York City averaged 75 cents and truck and water shipments 71 cents. Average preservation costs per box on shipments to the five markets were: Precooling, 9.5 cents; initial icing, 10.3 cents; precooling and initial icing combined, 18.1

cents; precooling and refrigeration, 27.3 cents; and standard refrigeration, 19.1 cents. There was no relationship between method of preservation and auction prices received when compared monthly. The average premium received for supergrade grapefruit over grade 1 was 40 cents per box and that of grade 1, 62 cents over grade 2. The prices of supergrade oranges averaged 54 cents per box more than those for grade 1, which exceeded the prices for grade 2 by an average of 42 cents per box.

Timber for handle stock.—The Indiana Station, in a study of marketing timber for handle stock found that $3 more per 1,000 board feet was received for white ash sold by log scale than when sold for a lump sum, and that a knowledge by farmers of the volume of standing timber or ability to measure logs was reflected in a greater stumpage return of from $2 to $9 per per 1,000 board feet.

TAXATION AND USE OF TAX FUNDS

Assessments.—The South Carolina Station in a study of over 1,500 farms for which appraisals had been made by lending agencies in 1935 and 1936 found that the average ratio of assessed value to appraised value was only about 24.6 percent, that the ratio decreased from 31.3 percent for farms appraised at $1,000 or less to 28.7 percent for those appraised at $1,000 to $2,000, and to 18.8 percent for those appraised at $15,000 or more; that the ratios decreased from 34.8 percent for farms appraised at less than $20 per acre to 13 percent for those appraised at $70 or more per acre; that taxes on an average took 13.85 percent of the estimated net returns from the farms; that the assessments on nearly one-third of the farms and two-fifths of the total value were less than 20 percent of the appraised value, while on over one-third of the number and one-fourth of the value it was at 40 percent or more; and that the average assessment ratios for all owner-occupied farms was 23.2 percent as compared with 26.8 percent for all farms not occupied by owners.

Studies of the Kansas Station show that the general property tax levied in 1936 on property engaged in agricultural production was $8.17 per $100 of gross agricultural income produced in 1935, while the levy on oil-producing property was equal to $1.50 per $100 gross income on such property, from March 1, 1935, to March 1, 1936.

Highway taxes in Colorado.—The Colorado Station, in a study of highway finances and taxes and the use of highways, found that Federal-aid highways carried 48.9 percent of all travel, other State highways 13.4, rural country roads 8.9, and city streets 28.8 percent. Nearly 77 percent of the travel originated in cities and towns, and over 23 percent in rural areas. Thirty percent of all highway taxes were paid by farm and rural residents, and 70 percent by city and town dwellers. A close relationship was found to exist between taxes paid and the amount of traffic originating in each section of the State. The three metropolitan counties in which 45.4 percent of the traffic originated paid 42.9 percent of the taxes, and the mountain counties in which 7.5 percent of the traffic originated paid 7.2 percent of the taxes.

Economics of county government.—A study by the Maryland Station of the development of local government, physical characteristics of counties, composition and distribution of population, reve-

nues and obligations of counties, present county government, and the possibilities of improving county administration by redistricting and substituting a limited executive plan for the present administrative organization resulted in the following findings:

Larger districts seem to be needed in order to eliminate duplication and overlapping of certain services. In some instances the geographical characteristics of the State seem to favor consolidation of the counties into larger units, because of the natural boundaries and other regional conditions. In addition to added efficiency and economy that would be possible by consolidation, assessments could be made more equal, government could be more comparable over the entire State, and greater equality of services would be received by all citizens. The major changes suggested for governmental reorganization, aside from the elimination of counties, are as follows: A reduction in the number of elected commissioners; limiting the duties of commissioners to policy-determination; appointing a limited executive to carry out the details of Board of Commissioners' policies; and appointing a director of each of the 6 county organization departments. Consolidating the counties of Maryland into 7 districts would reduce the annual cost of county government by an amount estimated at $577,000 under the 1935–36 cost. General administration, recording services, and law and order expenses are the ones most likely to be reduced under the redistricting plan suggested. Those costs most affected by the redistricting would be reduced an average of 28 percent, while the total tax levies would be reduced 5 percent, or 65 cents per capita. In addition to this economy, consolidation should increase the efficiency of service rendered for the money expended.

TENANCY AND TENURE

Tenure in Palo Alto County, Iowa.—The Iowa Station in cooperation with the extension service of that State, the Department of Agriculture (R.A.), and the Palo Alto County Agricultural Planning Committee in a study of the tenure history of 35 farms for an average period of 37 years showed that the farms had been owned by 89 persons and occupied by 45 owners and 142 tenants. The owners occupied the farms an average of 15 years with 24 percent staying 5 years or less. The average term of occupancy of the tenants was 4½ years; 49 percent stayed 2 years or less; 75 percent, 5 years or less; and only 6 percent, 15 years or more. A survey of 344 families in 15 townships showed that 27 percent were owner operators, 69 percent tenants, and 4 percent hired men. Of the owners 45 percent, of the tenants 36 percent, and of the hired men 13 percent were members of organizations, and 81, 74, and 53 percent, respectively, belonged to churches. Eighteen percent of the owners and 41 percent of the tenants had lived in the same school district only 4 years or less.

Increase in tenancy.—A study by the North Dakota Station based on United States census data brought out the fact that the percentage of farms in the State operated by tenants increased from 25.6 in 1920 to 39.1 in 1935. Of the tenants in 1934, 56.9 percent had been on the farms 4 years or less and only 11 percent over 15 years. Of the owners, 18.2 percent, and of the part owners 12.7 had occupied their farms 4 years or less, and 55.8 and 55.6 percent, respectively, had occupied their farms 15 years or more. A similar study by the Missouri Station showed that the number of tenants in that State increased from 85,000 in 1925 to 108,000 in 1935. In the latter year 37 percent of all farm lands of the State and nearly 50 percent of the farms in the general farming and grain-producing area in the northwestern part of the State were operated by tenants. In 1935, 34 percent of the tenants had been on their farms less than 1 year

and another 15 percent less than 2 years, while 45 percent of the owners had occupied their farms 15 years or over, and another 30 percent from 5 to 14 years. In the study by the Missouri Station and another study by the Iowa Station the legal, economic, and social consequences of existing laws pertaining to landlord-tenant relationships were studied and suggestions made for improving conditions.

Tenancy and maintenance of soil productivity.—Studies in four counties of Ohio by the Ohio Station showed that productivity of the soil was being maintained on 23 percent of the farms operated by owners, on 20 percent of the farms operated by tenants related to the owner, and on 7 percent of those operated by unrelated tenants. Soil productivity had been depleted more than 0.5 percent annually on 17 percent of the owner-operated farms and on 31 percent of the tenant-operated farms.

A study by the Oklahoma Station of soil erosion on farms in Kiowa County showed that the degree of erosion on owner- and tenant-operated farms was practically the same (2.22 and 2.23), although the average slope was 1.9 percent in the tenant farms and 2.27 in the owner farms. Part-owned farms had less degree of slope, 1.75 percent, and a smaller degree of erosion, 2.1 percent.

PRICE

State index numbers.—Monthly "all products" and commodity-group index numbers of farm products were constructed in a number of States. The Arkansas Station's series based on 25 of the most important farm products of the State showed that during the years 1910–37 the annual indexes were above those for the United States for 13 years and below for 15 years; that since 1931, with the exception of 1934, Arkansas prices have been lower than those of the United States; and since 1920 the trend of prices in Arkansas has been definitely downward, largely due to the decline in the prices of cotton and the importance of cotton as a source of cash income. The indexes for 1937 (1909–14=100) were: All products 99, cotton 96, fruits 106, dairy products 119, and meat animals 131. The lowest all products index was 51 in 1933.

A study of prices, quantities, and values of the cash sales of farm products during the period 1925–35, made by the Minnesota Station, showed that the indexes of prices based on 13 of the principal agricultural products declined from 105 (1924–26=100) in 1929 to a low of 41 in 1932, and then rose to 78 in 1935. The quantity index of crop sales was below 75 for the period 1927 to 1935. That for livestock sales increased considerably following 1930, while that for livestock product sales increased throughout the period, reaching 124 in 1933, but declined to 106 in 1935, due to drought. In 1932 the income from crop sales was only about 22 percent of that of the base period, that from livestock 42 percent, and that from livestock products 55 percent. Another study by the station of seasonal variations in prices and marketing showed that the month-to-month changes in the prices of crops are highly irregular and only a few months meet the statistical test for evidence of an underlying seasonal movement. Livestock and livestock products showed price movements sustained for longer periods of the year and with the excep-

tion of cattle, one-half or more of the months gave evidence of dominant seasonal movements. The average seasonal rise in the price of crops following harvest was not sufficient during the period studied (1921–35) to have materially increased the average price received under any regular plan of marketing followed consistently from year to year.

Among other States publishing series of price indexes are Michigan, South Dakota, and Montana.

CREDIT

Montana farm bankruptcies.—A study by the Montana Station covering the period 1898 to 1937 showed that in the 40 years nearly 3,900 farm-bankruptcy cases had been concluded in the Federal courts of the State, with a loss to creditors of over $40,000,000. The average ratio of assets to liabilities of the farmers who owned all or part of their land was 35 percent, and for those who owned no land 12 percent. The real-estate mortgages on the bankrupt farms averaged $15.38 per acre, exclusive of chattel mortgages and other claims, compared with approximately $6 per acre for all farm real-estate mortgages. In 23 counties where soil-classification data were available the real-estate debt of bankrupt farmers averaged approximately one and three-fourths times the long-time productivity value of the land, as compared with less than two-thirds in the case of farms mortgaged but not foreclosed on or the owners declared bankrupt. The proportion of tenants declared bankrupt was two to four times that of owners, varying at different times of the study. Bankrupt farms were considerably below the average in size, and were too small in most cases to constitute an economic operating unit. The station states:

> Bankruptcies and farm failures can be reduced in the future by: (1) basing loans on the productivity value of the lands as determined by a scientific soil survey and average yields and prices; (2) assessing lands for tax purposes in line with such productivity values, thereby reducing costs and increasing the debt paying possibilities of the farmer; and (3) adjusting annual loan repayments to current income and in terms of buying power rather than dollars.

Farmers' ability to repay loans.—The Kansas Station found that in the north-central part of the State during the period 1931–36 a farmer's chances of paying his farm debt from farm earnings were small if the debt exceeded three times the average annual cash income of the farm. The average part-owned farm could carry a maximum debt without principal payment twice that of the average rented farm and one and a half times that of the average owned farm. Without principal payments the debt-carrying capacity in ratio to cash income was 2.8 for poultry and dairy farms, 2.2 for cash grain farms, and 1.0 for hog farms.

Costs of credit.—In a study by the South Carolina Station it was found in one county that the number of farm-mortgage loans at 8 percent decreased from 80 percent of all loans in 1920 and 85 percent in 1930 to 4 and 2 percent, respectively, in 1934 and 1935. Five-percent loans were negligible before 1933, but constituted 32 percent of all loans in 1933, 52 percent in 1934, and 30 percent in 1935. Loans at 7 percent increased from 5 percent in 1933 to 9 percent in 1934 and 43 percent in 1935.

LABOR REQUIREMENTS

Seasonal requirements on Arizona irrigated farms.—The Arizona Station in a study in cooperation with the Federal Works Progress Administration and the Department of Agriculture (R.A.) found that in 1935, 1,369,000 man-days of regular hired labor (hired by the month or year) and 3,054,000 man-days of seasonal labor were used in the Salt River, upper Gila, Yuma-Gila, Santa Cruz, and Casa Grande Valleys. The total cost of such labor was nearly $7,000,000. The estimates for 1936 were 5,250,000 man-days costing nearly $9,000,000, and for 1937 over 5,700,000 man-days costing over $10,600,000. In 1935 the requirements for regular labor were fairly evenly distributed throughout the year, ranging from 110,000 man-days in March to 119,000 man-days in July. The seasonal labor required varied from only 89,000 man-days in March to 559,000 man-days in November. The cash income from irrigated farms in 1936 was approximately $35,000,000 as compared with less than $31,000,000 in 1935, an increase of approximately 13 percent, while the estimated increase in the cost of labor was approximately 29 percent.

Migrating labor in the hop industry.—Studies by the Washington Station have shown that despite the relatively small acreage of hops in the Yakima Valley, the hop industry accounts for approximately 47 percent of the demand for hired labor in the valley, that virtually all the labor on hops is needed during the 3-week period of harvest and that 25,000 to 35,000 transient workers must come into the valley during the height of the picking season. A study by the station in cooperation with the Federal and State Works Progress Administration covering the 1937 hop harvest showed that about 17 percent of the pickers claimed permanent residence in the Yakima Valley, about 32 percent in other sections of Washington, 13 percent in California and Oregon, 31 percent in the West Central and Mountain States, and 6.5 percent in other sections of the United States. Nearly one-half of the heads of families and three-fourths of the family members earned less than $2 per day. In the samples studied, one-eighth of the single persons and 40 percent of the families had received relief or other direct financial aid during the preceding year. Over five-eighths of the single persons and three-eighths of the families had received less than $401 of cash income during the preceding year. The cash assets of nearly 80 percent of the single persons and 45 percent of the families were $200 or less. Less than one-third of the pickers had a definite job awaiting them when the hop harvest was completed.

RURAL SOCIOLOGY

Membership of farmers in organizations.—The New York (Cornell) Station, from data obtained from 2,925 farmers in 4 counties, found that on an average the farmers belonged to 1.8 organizations, 21 percent belonging to no formal organizations, 29 percent to only 1 organization, 37 percent to 2 or 3 organizations, and 13 percent to 4 or more. Ownership of the farm operated, operations of a larger rather than a smaller farm, operation of a farm with higher assessed valuation, and stability of residence rather than frequent shifting, were the characteristics likely to distinguish the farmers belonging to several organizations from those belonging to none or only one. Age

and farm experience of operators over 30 years of age and location of farms as to type of roads seemed to have no influence. Members of the farm bureau were more likely, and members of the church, in the main, the least likely to belong to other organizations.

Activities of rural young people.—The Missouri Station, in cooperation with the Federal Works Progress Administration, in a study of 1,295 farm and 1,002 nonfarm young people, mostly from 16 to 24 years of age, attending high schools in 12 counties of the State, found that while nearly 93 percent of the former and nearly 77 percent of the latter had regular responsibilities at home, only 5.4 percent received pay directly for such activities. Approximately one-third of the boys and one-sixth of the girls had work for pay outside the home. Nearly 47 percent of all the persons included in the study had not earned any money during 1935, while nearly 40 percent had earnings of $75 or less. Over 8 percent of the young people attending school boarded and roomed in the vicinity of the school. About one-half of such persons worked for their board and room or both. Organizations sponsored by churches were attended by the greatest number of all the young people. Farm organizations in the case of farm boys and national youth organizations in the case of village and town boys were important groups attended. Other than church organizations, societies connected with the school were the most significant for girls. About one out of five of the young people were or had been members of 4–H Clubs.

Part-time farming in Pennsylvania.—A study of 887 part-time farms in six industrial areas in Pennsylvania by the Pennsylvania Station showed the average net farm income (commuting costs not deducted) was $1,029, of which $189 came from part-time farming, $773 from nonagricultural employment, and $67 from miscellaneous sources. Of the $621 average receipts from the farm $222 was from products sold, $242 for products consumed, and $149 allowed for use of dwelling. Livestock and livestock products accounted for 77 percent of the farm receipts. The study showed that part-time farming is primarily a market for surplus labor, the average return for labor so used being only 12.7 cents per hour as compared with 45 cents in industry. An average of 186 8-hour days of labor were spent on the farms, of which 44 percent was performed by the male head of the family, 26 percent each by the housewife and children, and 4 percent by other adult members of the household. The highest average total and per-hour labor earnings from the farming operations were in families having seven or more members, those with the head of the family between 35 and 44 years of age, those with earnings of $1,250 or less from nonagricultural occupations, and those with the head of the family having more than a high-school or college education. Total earnings were higher but earnings per hour less as the number of acres in crops, days of labor, and capital invested in land and buildings increased. Both increased with increased investments in livestock and machinery. Tenants had as high economic returns from part-time farming as owners and a much smaller investment of capital. Only church organizations, lodges, and labor unions were supported by a significant proportion of families.

School communities.—The Michigan Station found that approximately four-fifths of the farm boys and girls of the State received

their elementary education in some 6,000 one-room schools in local neighborhoods and that those going beyond the eighth grade did so as nonresident tuition pupils in schools located in some 533 villages and cities. The school districts in southern Michigan offering 12 grades had an average area of 13 square miles but served an average area of 88 square miles, while those in the Upper Peninsula had an average area of 92 square miles and served 232 square miles. The high-school communities ranged from less than 10 square miles to over 500 square miles, the areas being closely related to population density. The average high school was attended by pupils from 13 school districts, but 69 high-school districts drew pupils from 25 to 63 districts. During the period 1920–31 nonresident pupils outnumbered resident pupils in 43 percent of the high schools. In the average high school with under 200 pupils enrolled, 45 percent of the pupils were nonresidents. For all ages the percentage of urban children attending school was higher than that of farm children, being 76 percent for those 15 to 17 years of age as compared with 58.5 percent. The station states:

It is recommended that the residents who live within each of the 533 high-school communities evaluate the advantages and disadvantages of a community school district which would provide educational and sociological opportunities to farm boys and girls somewhat on a par with those now offered the village and city child. The procedure for the consolidation of districts is by petition in the respective territories to be united. School districts within urban centers have merged and been unified in the interests of economy, efficiency, and maximum educational and social benefits to pupils. A unification of the school districts within the tributary area of villages and larger population centers is equally necessary and would be similarly beneficial.

In a study of the influence of central rural schools on community organizations made in 15 such districts in New York, the New York (Cornell) Station found that through added facilities such as auditoriums, gymnasiums, and playgrounds the use of the school buildings for community purposes outside the school hours is stimulated and that such schools may be called community centers. The change in the school system had little influence on the existing organizations except in certain instances. Most of the new organizations were outgrowths of the school programs. In many places the parent-teacher association by its direct contact with parents serves as the most important organization in creating a cooperative spirit among the people. The trade area was usually not enlarged by the organization of a central school but more people in the area were brought into closer relationship with the village center. Smaller villages and communities other than those in which school buildings were located showed a stimulated condition of local activity and emphasis placed on the maintenance of community solidarity. The closing of the one-room schools in many instances removed the last institution from the neighborhood localities. Village and country relationships were improved by central school districts. Distinctive community life and community organization was more evident in those central districts where a single village served as the center of trade and organization.

Relief.—A study by the Oklahoma Station in cooperation with the Federal Emergency Relief Administration of rural and urban families receiving work or direct relief at Ottawa County, Okla., in December 1934, showed that 64 percent of the persons residing in the open

country, 60 of those in villages, 47 in towns, and 35 percent of those in cities were dependent on the Emergency Relief Administration for a major portion of their living. Of the heads of families receiving relief 27 percent were unskilled laborers, 21 farm tenants, 11 farm owners, 12 miners, 6 farm laborers, and the remaining 23 percent reported other occupations or no usual occupation. Approximately one-half of the farms operated by relief families were less than 50 acres in size, and three-quarters less than 100 acres. No work stock was owned by one-third of the owners and one-quarter of the tenants. One-sixth of the farm operators had no milk cow, and only one-quarter had a minimum of farm equipment, a large majority having no equipment except a plow. Of the heads of the relief families, 45 percent were 45 years of age or older. Of the total relief population over one-half were under 25 years of age, and two-thirds of such persons resided in rural communities.

A study by the Colorado Station in cooperation with the Federal Works Progress Administration of the composition and behavior of 357 rural households receiving public emergency relief in October 1933, and 714 nonrelief rural families in Baca, Elbert, and Laramie Counties, Colo., showed that the households engaged in agriculture in the relief group had a relatively higher proportion of tenants and laborers and a smaller proportion of owners. In the nonagricultural occupations, the relief group had a relatively higher proportion of unskilled laborers and a smaller proportion of skilled workers, proprietors, and clerical workers. Heads of relief households tended to be under 35 or over 54 years of age, while those of the nonrelief group were more frequently from 35 to 54 years of age. Children under 16 years of age constituted about 46 percent of the persons on relief and about one-third of those not on relief. Families with only one parent present constituted 11 percent of the relief and 4 percent of the nonrelief households. The households receiving relief averaged about one-half person more and included one-third more children under 16 years of age than did the nonrelief families. Male heads of relief households averaged six and one-half grades of school as compared with about eight for the nonrelief heads. Farm operators on relief operated much smaller farms and had less livestock than the nonrelief operators. The relief households did less part-time farming, earned less from supplementary employment, and had moved more frequently from county to county and from farm to farm. The ratio of advances to set-backs in climbing the "agricultural ladder" had been 38 percent better for nonrelief household heads engaged in agriculture. The station states that the study—

> has shown that each county has distinctly different population characteristics and behavior, which means that each has distinct social and economic problems. Finding these differences shows the necessity for studying the rest of the State to determine areas having common characteristics. The discovery of these variations in the social patterns has implications for all programs and agencies working in rural areas; they infer the necessity of adapting plans to local conditions rather than attempting stereotyped procedures on a State, regional, or Nation-wide basis if the greatest measure of achievement would be secured.

The South Dakota Station in a study made in cooperation with the South Dakota Public Welfare Commission and the Federal and State Works Progress Administrations of the extent of dependency upon old-age assistance as shown by the applications during the first

4 months (October 1936 to February 1, 1938) under the South Dakota plan for such assistance, found that there were relatively more needy aged persons in the open country and rural areas than in town and city areas, that the number was relatively less among the foreign-born than the native-born population, that dependency tended to increase with age, and that the aged differed to a marked extent in need according to age and sex. A further study of the social and economic status of the applicants showed that about 70 percent of all male applicants gave farming as their usual occupation and that over 50 percent of the country applicants had 45 years or more of farming experience. No change of residence had been made by about four-fifths of the applicants during the 9 years prior to applications. Approximately 50 percent of the children of applicants lived in the same county as the applicants, about 17 percent of the sons and 20 percent of the daughters in other counties of the State, and about one-third resided outside the State. The study pointed to the conclusion that farm tenancy and old-age dependency are associated with each other and are probably related as cause and effect.

Standards of living.—The South Dakota Station, in cooperation with the Works Progress Administration and Department of Agriculture (F.S.A. and B.A.E.), in a study of 1,101 open-country and 774 village families in 6 counties in 1935, found the average living expenses for the open-country families was $1,111 and that of the village families $874. The distribution of expenditures for the two types of families were: Housing and maintenance $261 and $278; food $484 and $279; clothing $96 and $88; health $50 and $42; advancement $42 and $49; automobile $120 and $76; and incidental and other expenses $58 and $62. The cash outlay for housing and maintenance was $138 and that for food $197 for the open-country families as compared with $216 and $253 for the village families. Size of family and income directly affected the proportion of expenditures for housing and maintenance and food. Duration of marriage and stage in the family cycle affected the clothing expenditures directly. Usually the standard of living was higher in the tenure and resident groups where the male heads and the homemakers of the families had the most education.

A study of 1935 by the Mississippi Station in Noxubee, Oktibbeha, and Winston Counties, Miss., of 125 white and 125 Negro farm families on submarginal lands and like numbers of white and Negro families of similar composition on land suitable for resettlement, showed the white families on the poorer soil netted an average of $36.19 from farm operation and those on the better soil $255.84, as compared with $88.66 for the Negro families on the poorer soils and $131.93 for those on the better soil. About 50 percent of the total cash expenditures of all the families were for family expenses, 40 percent for farm expenses, and 10 percent for investments. The average expenditures for family living were: White families on the poorer soils $197.61 as compared with $313.06 for those on the better soil, and $150.84 for the Negro families on the poorer soil as compared with $184.75 for those on the better soil. The Station states—

> the greater difference in the manner of living between white families on the two soil areas (where families on the more fertile areas were also more frequently landowners and had more schooling) than in the manner of living

between Negro families on the two soil areas (where families on the more fertile areas were less frequently landowners and had less schooling) indicates that soil fertility is only one factor affecting the manner in which a farm family lives. The fact that Negro families on less productive soil (the group with more landowners and better education) more often had a water supply on their farm, more often had labor-saving equipment, more often subscribed to periodicals and spent more on the education of their children than Negro families on more productive soil also seems to bear this out. * * * From the data secured in this study it would seem that greater improvement in the level of living of the Negro family could be made by movements from poorer to better soil than in the case of the white family.

PART 3—STATISTICS OF THE EXPERIMENT STATIONS

Data regarding the projects, personnel, publications, and mailing lists; income; expenditures from the Federal-grant and supplementary funds; additions to equipment; and total disbursements from the United States Treasury under the Hatch, Adams, Purnell, and Bankhead-Jones Acts from their passage to the end of the fiscal year, June 30, 1938, are shown in the tables which follow.

PROJECTS

The projects and programs of research of the stations were revised and adjusted in many instances during 1938 in order that more attention could be given to conservation problems and adjustments to utilize the agricultural resources more economically and to meet the needs for agricultural commodities more effectively. The number of formal research projects active during the year at the stations was increased to about 8,500. They covered practically every major field of agriculture and home economics, including rural life and related interests.

The numbers of projects supported by the Adams, Purnell, and Bankhead-Jones funds showed an increase during the year due to the increase of $600,000 appropriated under the Bankhead-Jones Act for research work in the States and Territories. From table 1 it will be noted that 505 Adams projects, 1,660 Purnell projects, and 695 Bankhead-Jones projects were under investigation during the year. Of the total of 2,860 projects financed under the three funds, 439 were new and 119 revised. Two hundred and eighty-six projects were completed during the year.

TABLE 1.—*Adams, Purnell, and Bankhead-Jones projects active at the experiment stations for the year ended June 30, 1938*

	Completed	Revised	New	Active
	Number	*Number*	*Number*	*Number*
Adams	45	21	41	505
Purnell	211	74	219	1,660
Bankhead-Jones	30	24	179	695
Total	286	119	439	2,860

PERSONNEL

In line with increased support from Federal and State sources, the technical personnel of the stations was increased in 1938 over 1937, the comparative figures being 4,219 and 3,924, a gain of 295

persons; 2,086 (approximately 50 percent) of these technical workers devoted full time to research, 1,923 divided time between research and resident teaching, 61 between research and extension work, and 149 gave some time to both resident teaching and extension work as well as research. The numbers of technical workers and their distribution between research and other activities for each of the stations are shown in table 2.

PUBLICATIONS

The publications of the stations in 1938 included 743 publications in the regular series of bulletins and circulars, 2,510 articles in scientific journals, and 571 miscellaneous publications. This represents an increase over 1937 when the comparative figures were 860, 2,042, and 488.

INCOME

The total income available to the stations for 1938 from all sources, including Federal grants and supplementary funds, the latter involving balances from the previous year, State appropriations, endowments and fellowships, fees, sales, and miscellaneous, was $19,848,068.43, as compared with $17,694,252.72 in 1937.

FEDERAL GRANTS

The Federal grants to the States, Territories, and Puerto Rico for agricultural research amounted to $6,232,500, as compared with $5,620,000 for 1937. Each State received $90,000 under the Hatch, Adams, and Purnell Acts, while Alaska received $22,500, Hawaii $50,000, and Puerto Rico $40,000. The $1,800,000 provided under the Bankhead-Jones Act was allotted on the basis of the respective rural populations of the States, Territories, and Puerto Rico. The amounts available to each are shown in table 3.

SUPPLEMENTARY FUNDS

The total of funds available from State sources was greatly in excess of the amounts needed to meet the offset requirements of the Bankhead-Jones Act, and no State failed to meet its individual obligation under the act. The total of State appropriations was $9,079,796.69 as compared with $7,445,105.33 in 1937, and the total from all supplementary sources, including State appropriations, was $13,615,568.43, as compared with $12,074,252.72 in 1937.

It will be noted that the States appropriated approximately $1.46 for each $1.00 received from Federal sources, and that the total supplementary income of the stations was in the ratio of $2.18 to each $1.00 of income from the Federal grants.

EXPENDITURES

Classified expenditures for 1938 from Federal appropriations are shown for each of the stations in tables 4 to 7, and expenditures from supplementary funds in table 8. Table 4 shows Hatch, table 5 Adams, table 6 Purnell, and table 7 Bankhead-Jones fund expenditures. The totals of disbursements to date to the States, Territories, and Puerto Rico under each of the Federal-grant acts are shown in table 10.

IMPROVED FACILITIES FOR RESEARCH

As shown in table 9, experiment station expenditures for additions to equipment in 1938 were $1,613,692.84. Of this amount $61,514.50 were expended for library purposes. The comparable figures for 1937 were $1,252,040.98 and $49,206.57. The following items are examples of the many improvements in physical plant: The library facilities of the Connecticut (Storrs) Station will benefit through the addition of a new $150,000 college library which was under construction during the year. A new $600,000 physical science building under way at Kansas State College will provide quarters for the work of the Kansas Station in the fields of physics and chemistry. An extensive building program was begun at Pennsylvania State College under joint financing of the P. W. A. and the State Building Commission. Among the 11 buildings included in the outlay of $5,000,000, the poultry service, forestry, agricultural engineering, and agricultural science buildings will provide much-needed space for the school of agriculture and experiment station. The cost of these 4 buildings is estimated to exceed $1,000,000. The work of the Maryland Station will likewise benefit directly through the construction of a $125,360 poultry building and plant, a $114,360 home economics building, new greenhouses to cost $37,000, and an allotment of $15,730 for remodeling the dairy building, these items being included in a major program of new construction at the University of Maryland for which provision was made during the year. The funds were derived in part from a W. P. A. grant and in part from State appropriations. A 3-story agricultural chemistry laboratory and an addition to the horticultural building were in progress at Purdue University. The University of Minnesota was erecting a new forestry building to cost $250,000.

Other structures designed for specific research uses included a headhouse and two greenhouses for horticultural and agronomic research at the South Carolina Station, also two office and laboratory buildings at the Pee Dee and Edisto Substations. A new cotton-research laboratory was fitted up at the Alabama Station in cooperation with the Department of Agriculture. The construction at Davis of a hydraulics laboratory for the joint use of irrigation and agricultural engineering was authorized by the regents of the University of California, and the University of Arizona projected a permanent laboratory for research on the relationship between tree rings and climatic cycles.

Acquisitions of land for experimental uses included a tract of 2,500 acres for research in biology by the Virginia Station; a 120-acre tract at the Missouri Station to be used in swine-improvement studies in cooperation with the United States Regional Laboratory; 237 acres for the experimental work in poultry and crops and soils of the Louisiana Station; and 200 acres at the Truck Substation of the South Carolina Station, part of which is to be used for field experiments. The University of Maryland received a valuable gift of farm properties, including a herd of Ayrshire cattle, and other livestock and poultry. Iowa State College was the recipient of a gift of nine farms with funds for maintenance, and the College of Agriculture of the University of California was deeded a tract of 110 acres at

Winters to be used for experimental work in pomology and allied fields.

Beside the foregoing items of physical plant improvement, the stations received noteworthy grants or endowments for agricultural research from private benefactors and State appropriations. The Michigan Station will receive the income from a trust endowment of $500,000 by the Horace A. Rackham and Mary A. Rackham Foundation of Detroit for agricultural and chemurgic research. A fund of $50,000 known as the Henry Strong Dennison Fund for Agricultural Research has been made available to Cornell University through a gift of Mrs. Ella S. Dennison, of Denver, Colo. The University of Missouri and the Missouri Station have accepted a grant of $2,500 from the International Cancer Foundation to extend investigations on hormones as related to mammary tumor production, and the Vermont Station is to receive the residue of the estate of the late Alma S. Clemens of Caledonia, N. Y., now valued at approximately $20,000 after certain bequests are paid and on the death of her son. New State appropriations for special research purposes included an appropriation to the New Jersey Station of $20,000 for research on Bang's disease and mastitis, and an appropriation to the Missouri Station of $14,800 for experimental field work in horticulture.

TABLE 2.—*Organization, personnel, publications, and mailing lists of the experiment stations for the year ended June 30, 1938*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications						Names on mailing list
			Full-time research	Research and teaching	Research and extension	Research teaching and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications		
								Number	*Pages*	*Number*	*Pages*	*Number*	*Pages*	
Alabama	Feb. 27, 1889	Apr. 1, 1888	35	30			65	7	121	26	174			4,000
Alaska	May 2, 1929	May 1, 1931	3		1		4	1	40					500
Arizona	Mar. 19, 1891	July 1, 1889	17	38			55	10	571	27	165	11	33	12,716
Arkansas	Mar. 7, 1889	Apr. 2, 1888	19	50	1	3	73	15	597	31	190			6,275
California	Mar. 12, 1889	Mar. 13, 1888	103	159			262	24	1,163	508	5,866	4	194	4,702
Colorado	Mar. 25, 1889	Feb. 20, 1888	24	42		1	67	20	936	14	28	26	52	600
Connecticut:														
State	May 18, 1887	May 18, 1887	42				42	17	953	19	111	16	70	14,000
Storrs	do	Apr. 1, 1888	17	9	2	5	33	7	251					11,000
Delaware	Apr. 14, 1887	Feb. 21, 1888	11	7	3	4	25	3	123					11,000
Florida	June 7, 1887	Mar. 16, 1888	68	10	5	5	88	24	571	35	143	64	260	18,000
Georgia	Dec. 24, 1888	Feb. 18, 1888	42				42	4	132	4	49	1	4	9,000
Hawaii	Mar. 31, 1911	July 1, 1929	12	17			29	5	224	7	26	12	63	1,422
Idaho	Jan. 23, 1891	Feb. 26, 1892	17	28	2	4	51	4	104	5	24			22,000
Illinois	May 11, 1887	Mar. 21, 1888	57	74	4	8	143	23	738	59	428	17	82	31,000
Indiana	Jan. 19, 1889	July 1, 1887	83	30	4	2	119	14	553	114	287	6	56	34,793
Iowa	Mar. 1, 1888	Feb. 17, 1888	59	107	8	3	177	28	1,377	96	713			24,431
Kansas	Mar. 4, 1887	Feb. 8, 1888	30	94		1	125	12	401	109	109	1	32	12,000
Kentucky	Feb. 20, 1888	Apr. 29, 1898	65	22		7	94	17	877	36	166	1	41	7,000
Louisiana	July 12, 1888	Apr. 5, 1887	46	17	1	1	65	11	340	40	230	1	592	996
Maine	Mar. 16, 1887	Feb. 16, 1888	32	6		1	39	4	337	7	109	4	182	18,860
Maryland	Mar. 6, 1888	Mar. 9, 1888	22	25	2	7	56	21	728	35	70	29	58	2,500
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	71	17			88	18	640	30	195	12	48	1,600
Michigan	Apr. 12, 1889	Feb. 26, 1888	51	79	6	5	141	17	877	26	177			14,000
Minnesota	Feb. 4, 1889	Jan. 26, 1888	47	125	2	3	177	12	540	114	228	123	246	1,156
Mississippi	Jan. 31, 1838	Spring 1888	31	24	1	1	57	2	53	4	26	31	47	5,000
Missouri	June 11, 1889	Jan. 31, 1888	20	72	1	2	95	38	1,967	49	98			2,283
Montana	Feb. 16, 1893	July 1, 1893	30	14	1	4	49	19	810	13	85	10	133	2,910
Nebraska	Mar. 31, 1887	June 14, 1887	23	45			68	28	742	14	28			500
Nevada	Feb. 8, 1889	December 1887	19	3			22	6	181	5	10			4,500
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	19	23	8	3	53	12	417			10	49	8,000
New Jersey:														
College	Mar. 16, 1887	Mar. 5, 1888	21	27	1	1	50	26	680	141	141	7	28	11,500
State			70				70							
New Mexico	Feb. 28, 1889	Nov. 14, 1889	11	20		2	33	40	448	3	22			8,885

New York:														
Cornell	Mar. 30, 1887	Apr. 30, 1888	26	116		10	152	23	1,297	283	1,731	11	422	53,648
State	(1)		76				76	20	318	73	146			24,471
North Carolina	Mar. 7, 1887	Dec. 5, 1889	47	20	1	5	73	14	561	7	134			4,386
North Dakota	Mar. 8, 1890	Oct. 15, 1890	25	21			46	3	592	4	17			17,500
Ohio	Mar. 16, 1887	Apr. 2, 1888	126				126	13	576	51	332	8	202	31,000
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	29	50		1	80	5	123	49	178	7	154	4,000
Oregon	Feb. 25, 1889	July 2, 1888	55	52		6	113	16	477	41	328	28	140	1,641
Pennsylvania	June 3, 1887	June 30, 1887		155			155	39	753	47	382			37,500
Puerto Rico	Aug. 16, 1933	Nov. 14, 1933	42				42	7	657			4	587	2,340
Rhode Island	Mar. 31, 1887	Nov. 3, 1888	12	11	1	5	29	6	215	11	70			2,206
South Carolina	Dec. 22, 1887	January 1888	46	19	1	1	67	6	433	10	37	2	16	3,500
South Dakota	Mar. 11, 1887	Nov. 17, 1887	5	32		3	40	13	528	14	28			5,506
Tennessee	Mar. 29, 1887	July 24, 1887	36	18			54	7	242	9	48			13,912
Texas	Apr. 2, 1887	Jan. 25, 1888	137	1		1	139	21	1,572	38	235	103	332	70,000
Utah	Mar. 8, 1888	Nov. 16, 1889	23	26		5	54	6	70	31	222			4,500
Vermont	November 1888	Feb. 28, 1888	20	12			32	13	381	4	27			4,004
Virginia	Feb. 29, 1888	June 13, 1888	39	14		5	58	11	246	8	69			12,000
Washington	Mar. 9, 1891	May 1, 1891	41	36			77	15	526	24	186	12	74	3,214
West Virginia	Feb. 22, 1889	June 11, 1888	17	28		5	50	5	94	19	122	1	8	12,000
Wisconsin	Session of 1889	July 1, 1887	45	72	5	29	151	5	432	210	420			64,000
Wyoming	Jan. 10, 1891	Mar. 27, 1891	22	26			48	6	174	6	27	9	16	8,000
Total			2,086	1,923	61	149	4,219	743	28,759	2,510	14,637	571	4,221	686,547

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.

TABLE 3.—*Experiment station income for the year ended June 30, 1938*

Station	Federal grants					Supplementary							Grand total
	Hatch fund	Adams fund	Purnell fund	Bankhead-Jones fund	Total[1]	Balance from previous year	State appropriation	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Total	
Alabama	$15,000	$15,000	$60,000	$62,021.34	$152,021.34	$141,328.68	$187,743.04			$76,718.18		$405,789.90	$557,811.24
Alaska	15,000	7,500		1,677.36	24,177.36	1,583.16	4,000.00			12,178.10		17,761.26	41,938.62
Arizona	15,000	15,000	60,000	9,316.92	99,316.92	1,692.57	113,334.83			1,057.43		116,084.83	215,401.75
Arkansas	15,000	15,000	60,000	47,987.40	137,987.40		115,290.34	$1,900.00		27,961.49		145,151.83	283,139.23
California	15,000	15,000	60,000	49,456.47	139,456.47	39,463.90	1,013,003.76	96,489.37		46,519.28		1,195,476.31	1,334,932.78
Colorado	15,000	15,000	60,000	16,823.22	106,823.22	25,798.99	79,222.37			39,781.35		144,802.71	251,625.93
Connecticut:													
State	7,500	7,500	30,000	7,746.78	52,746.78		218,337.72	5,951.31	$27,836.49			252,125.52	304,872.30
Storrs	7,500	7,500	30,000	7,746.78	52,746.78		44,638.00		5,742.02			50,380.02	103,126.80
Delaware	15,000	15,000	60,000	3,757.65	93,757.65	3,541.88	24,662.79			15,879.80		44,084.47	137,842.12
Florida	15,000	15,000	60,000	23,101.23	113,101.23	18,588.92	419,040.00			50,198.94		487,827.86	600,929.09
Georgia	15,000	15,000	60,000	65,642.19	155,642.19	2,953.96	73,379.19			25,467.93		101,801.08	257,443.27
Hawaii	15,000	15,000	20,000	6,889.80	56,889.80	2,119.52	6,889.80	1,795.99		17,891.25	$36,906.84	65,603.40	122,493.20
Idaho	15,000	15,000	60,000	10,288.92	100,288.92	12,181.02	20,504.92			20,133.52		52,819.46	153,108.38
Illinois	15,000	15,000	60,000	65,052.39	155,052.39		386,823.57	22,242.96		52,410.42		461,476.95	616,529.34
Indiana	15,000	15,000	60,000	47,041.95	137,041.95	370,834.20	269,500.00	76,655.89	160,896.40	126,310.69	29,126.68	1,033,323.86	1,170,365.81
Iowa	15,000	15,000	60,000	48,640.98	138,640.98	17,115.06	221,568.54	39,996.62		28,323.24	7,587.43	314,590.89	453,231.87
Kansas	15,000	15,000	60,000	37,538.22	127,538.22	21,814.52	120,865.00		60,076.85		2,060.00	204,816.37	332,354.59
Kentucky	15,000	15,000	60,000	59,203.53	149,203.53	2,204.45	99,696.35		166,522.21	46,735.76	209.60	315,368.37	464,571.90
Louisiana	15,000	15,000	60,000	41,350.08	131,350.08	7,306.27	96,500.00	7,667.47			7,407.55	118,881.29	250,231.37
Maine	15,000	15,000	60,000	15,519.12	105,519.12		36,305.28	1,600.00	20,046.96	6,770.51	337.90	65,060.65	170,579.77
Maryland	15,000	15,000	60,000	21,412.86	111,412.86	11,664.64	87,168.74	7,879.06	2,310.52	27,958.69		136,981.65	248,394.51
Massachusetts	15,000	15,000	60,000	13,636.65	103,636.65		204,096.65	9,207.86		1,450.00		214,753.91	318,390.56
Michigan	15,000	15,000	60,000	50,225.88	140,225.88		255,936.84			26,032.80		281,969.64	422,195.52
Minnesota	15,000	15,000	60,000	42,598.23	132,598.23		379,127.91	7,300.00	1,012.85	65,525.77		452,966.53	585,564.76
Mississippi	15,000	15,000	60,000	54,488.55	144,488.55	72,949.83	86,724.30	1,003.00	13,446.47	60,946.74		235,070.34	379,558.89
Missouri	15,000	15,000	60,000	57,725.85	147,725.85	37,608.25	89,749.06	20,533.89	28,104.11	43,266.76		219,262.07	366,987.92
Montana	15,000	15,000	60,000	11,627.37	101,627.37	22,426.68	70,925.62			43,096.74		136,449.04	238,076.41
Nebraska	15,000	15,000	60,000	29,082.45	119,082.45		138,782.82			75,429.61		214,212.43	333,294.88
Nevada	15,000	15,000	60,000	1,845.48	91,845.48	6,498.53	3,101.88			7,941.85		17,542.26	109,387.74
New Hampshire	15,000	15,000	60,000	6,267.90	96,267.90	21,402.02	6,267.90			2,495.40	21,147.11	51,312.43	147,580.33
New Jersey:													
College	15,000	15,000	60,000	22,894.38	112,894.38								112,894.38
State							512,090.00					512,090.00	512,090.00
New Mexico	15,000	15,000	60,000	10,320.75	100,320.75	35,655.38	12,320.00			15,881.17	1,700.00	65,556.55	165,877.30
New York:													
Cornell	13,500	13,500	54,000	60,636.36	141,636.36		623,505.83			84,013.45	1,725.19	709,244.47	850,880.83
State	1,500	1,500	6,000	6,737.37	15,737.37	3,673.66	373,601.52			18,154.41		395,429.59	411,166.96

North Carolina	15,000	15,000	60,000	76,971.00	166,971.00	2,729.85	94,148.32	2,650.00		15,377.80	366.37	115,272.34	282,243.34
North Dakota	15,000	15,000	60,000	18,506.82	108 506.82	2,138.19	88,333.00	1,000.00	1,909.50	45,230.24		138,610.93	247,117.75
Ohio	15,000	15,000	60,000	69,761.07	159,761.07	158,630.42	561,891.58			103,584.92	7,743.00	831,849.92	991,610.99
Oklahoma	15,000	15,000	60,000	51,338.13	141,338.13	20,439.29	274,317.17		40,318.92	30,830.16		365,905.54	507,243.67
Oregon	15,000	15,000	60,000	15,131.85	105,131.85	189,770.11	143,266.05	4,633.98	43,119.24	49,240.29		430,029.67	535,161.52
Pennsylvania	15,000	15,000	60,000	101.017.14	191,017.14	4,186.32	118,806.70			42,470.92	15,713.03	181,176.97	372,194.11
Puerto Rico	15,000	15,000	10,000	36,414.12	76,414.12		140,976.68					140,976.68	217,390.80
Rhode Island	15,000	15,000	60,000	1,697.88	91,697.88	2,025.66				9,349.48		11,375.14	103,073.02
South Carolina	15,000	15,000	60,000	44,598.72	134,598.72	8,166.04	105,305.91			92,983.09		206,455.04	341,053.76
South Dakota	15.000	15,000	60,000	18,324.33	108,324.33	19,550.36	23,260.00	2,466.90		15,201.65		60,478.91	168,803.24
Tennessee	15,000	15,000	60,000	56,087.91	146,087.91		36.082.39			33,389.57		69.471.96	215,559.87
Texas	15,000	15,000	60,000	112,023.57	202.023.57	75,868.62	411,633.00			157,507.85	111,228.31	756,237.78	958,261.35
Utah	15.000	15,000	60,000	7,877.76	97,877.76	4,510.78	37,500.00	1,784.51		13,753.50	4,923.42	62,472.21	160,349.97
Vermont	15,000	15,000	60,000	7,853.70	97,853.70	541.49			26,649.12	665.01		27,855.62	125.709.32
Virginia	15.000	15.000	60,000	53,358.42	143,358.42	387.59	84,150.00	9,915.00		6,629.50		101,082.09	244,440.51
Washington	15,000	15,000	60,000	22,136.79	112,136.79		190,740.38	1,541.59		36,061.20		228,343.17	340,479.96
West Virginia	15,000	15,000	60,000	40,360.08	130,360.08	13,558.46	44,500.00	800.00		36,267.96	1,400.00	96,526.42	226,886.50
Wisconsin	15,000	15,000	60,000	45,168.66	135,168.66		324.283.88	75,365.60		57,343.60		456,993.08	592,161.74
Wyoming	15,000	15,000	60,000	5,069.64	95,069.64	61,337.07	5,897.66			30.868.30	283.99	98,387.02	193,456.66
Total	765,000	757,500	2,910,000	1.800,000.00	6,232,500.00	1,444,246.34	9,079,796.69	400,381.00	597,991.66	1,843,286.32	249,866.42	13,615,568.43	19,848,068.43

[1] Including unexpended balances—Illinois, Hatch $0.04, Adams $0.25, Bankhead-Jones $9.47; New York State, Purnell $0.02; Puerto Rico, Hatch $19.90, Adams $1,501.81, Purnell $217.76, Bankhead-Jones $1,746.76; Rhode Island, Adams $0.43, Purnell $0.37.

TABLE 4.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$15,000	$10,975.20	$1,401.12	$336.06	$266.89	$112.46	$50.00	$54.74	$266.71
Alaska	15,000	5,671.12	5,602.62		250.42	183.19	759.36	38.74	469.08
Arizona	15,000	14,951.76			48.24				
Arkansas	15,000	8,961.47	2,256.47	419.47	230.64	.74	206.32	530.97	661.13
California	15,000	15,000.00							
Colorado	15,000	14,908.00							
Connecticut:									
State	7,500	7,500.00							
Storrs	7,500	5,912.50			11.66	2.64			2.94
Delaware	15,000	8,631.66	1,814.98	1,055.15	934.82	5.20	317.53	160.67	137.99
Florida	15,000	14,890.00	110.00						
Georgia	15,000	6,990.07	2,804.62	526.28	978.63	32.45	529.69	37.73	573.86
Hawaii	15,000	9,006.36	2,911.01	927.39	176.42	35.00		406.77	264.95
Idaho	15,000	8,136.96	2,504.62	951.15	941.58	19.70	26.05	254.21	73.61
Illinois	15,000	14,430.85	569.15						
Indiana	15,000	15,000.00							
Iowa	15,000	15,000.00							
Kansas	15,000	9,700.00	4,450.14	51.07	35.38		8.75	60.67	45.13
Kentucky	15,000	13,491.57	331.29	1,086.19					
Louisiana	15,000	8,550.00	4,881.16	710.22	227.80	1.35	61.35	2.50	27.25
Maine	15,000	8,600.03	1,001.16	124.35	1,088.11	112.29	1,045.75	99.69	198.78
Maryland	15,000	12,728.28	798.00		186.00	11.42	19.15	63.04	53.22
Massachusetts	15,000	12,286.75	1,608.95	460.73					7.84
Michigan	15,000	15,000.00							
Minnesota	15,000	14,409.14	41.60		5.00	2.19		203.79	7.11
Mississippi	15,000	7,993.04	1,299.74		975.92	64.55	251.76	212.17	126.50
Missouri	15,000	14,277.60	635.95	2.83	83.62				
Montana	15,000	7,475.16	3,096.34	1,412.99	1,370.55	10.72	576.67	4.89	99.05
Nebraska	15,000	14,475.00	525.00						
Nevada	15,000	7,650.00	779.12	723.77	537.40	112.13	285.27	2.94	151.88
New Hampshire	15,000	8,691.00	829.89	755.46	918.22	324.62	700.00	87.79	152.78
New Jersey	15,000	11,767.97	409.87	150.18	287.12	50.05	31.03	380.91	171.13
New Mexico	15,000	8,772.49	3,490.49	815.77	132.63	108.09	146.56	353.07	531.18
New York:									
Cornell	13,500	7,210.00	4,898.96		125.63			883.33	205.20
State	1,500	1,208.81	291.10		.09				
North Carolina	15,000	10,538.00	358.50	700.42	411.70	20.34		229.60	37.56
North Dakota	15,000	12,012.57	901.18	255.77	309.40	25.47	28.23	78.57	8.00
Ohio	15,000	4,100.00		1,018.90	293.74	62.86	2,487.43	1,797.21	130.54
Oklahoma	15,000	6,515.34	3,207.33	76.19	298.99	116.60	74.38	214.85	920.01
Oregon	15,000	7,746.00	5,461.29	499.33	172.78		58.25	12.50	63.85
Pennsylvania	15,000	8,985.00	1,251.67	2,271.38		12.43	6.45		38.85
Puerto Rico	15,000	6,880.00	2,303.60	1,022.65	338.70	3.00		4.25	30.89
Rhode Island	15,000	8,752.84	2,648.79	282.68	642.19	23.18	148.53	122.71	512.85
South Carolina	15,000	9,262.46	1,415.45	595.00	831.28	5.66	5.31	143.90	80.18
South Dakota	15,000	7,099.67	3,015.66	1,673.51	103.75	45.64	17.60	43.44	452.40
Tennessee	15,000	8,760.00	3,627.68	1,129.17	594.16	76.13	23.50	11.29	57.29
Texas	15,000	13,170.95	195.50	30.00	183.37			21.98	70.52
Utah	15,000	8,666.61	2,607.65	353.64	52.92	10.56		344.18	330.54
Vermont	15,000	8,206.90	2,600.01	1,409.39	243.72	8.73	879.67	186.85	261.89
Virginia	15,000	8,669.81	5,403.89		170.07		3.81	27.74	292.07
Washington	15,000	9,601.80	2,938.72	1,041.14	258.26	.83		28.54	119.85
West Virginia	15,000	9,645.81	2,754.19	757.49	31.38	81.02	281.20	174.31	24.78
Wisconsin	15,000	14,274.66			1.86				
Wyoming	15,000	6,295.00	4,416.22	679.16	788.77	45.88	942.51	91.71	398.22
Total	765,000	529,436.21	94,450.68	24,304.88	15,539.81	1,727.12	9,972.11	7,372.25	8,057.61

the act of Mar. 2, 1887 (Hatch Act), for the year ended June 30, 1938

Expenditures—Continued											
Fertilizers	Feeds	Library	Machinery, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
$39.00		$383.32	$112.65	$476.74	$217.25		$2.55	$8.38	$296.93		
99.37	$318.85		225.82	336.90		$25.00	276.38	4.00	739.15		
117.69	759.69	26.08	389.66		202.89	50.00	118.29		68.49		
							92.00				
		579.40	199.72		585.20		200.00				$5.94
58.78		741.51	35.30	681.89	7.28		410.74	6.50			
185.85	424.63	230.67	314.07	264.90	.30	125.00	929.18	38.70	13.37		
43.50		22.65		43.00	1,037.95		125.00				
	231.17	28.46	107.90	102.00	415.18		1,169.21		38.20		
35.73	.65	28.32	63.68	57.83	155.90		285.92		20.83		
		18.45					72.50				
			239.86	97.35			201.16				
35.80	160.20	992.85	70.87	398.26	9.22	39.65	682.85	118.23	221.91		
54.00	988.84		1.96				96.09				
			17.15	56.84			561.74				
	7.57	7.80		77.09	50.50		188.21				
		51.75	1,486.94	1,270.43	69.79	1.62	1,167.41	18.15	10.23		
45.00	327.83	205.90	43.55		55.15		261.77	14.43			
	1,471.22	8.75	92.61	323.36	332.10	1,983.45	164.46	122.19	259.35		
53.17	207.50	603.09	62.57	331.51	655.66		626.74				
69.87	360.00	250.26	184.16	205.94	84.23		563.22	27.84	6.22		
			222.22	30.91	35.25		259.39	101.95			
7.80			53.51		109.69			5.88			
			449.60	519.89	635.25		845.47		253.67		
	373.95	51.83	159.05	303.05	53.15		402.08	5.00	31.43		1.27
448.67	554.79	105.00	2,808.33	224.42	236.85		182.96		548.30		
45.95	1,191.66	10.10	495.53	249.82	495.86	442.61	376.71		268.07		
90.02			17.07	150.70	13.50		706.51	8.20			
30.66			408.00		1,976.96		18.60				
		84.91	25.00	2,037.00	878.62		1,378.42	10.00			2.96
405.60	23.25	253.23	457.99	66.22	146.74		280.50	21.00	211.70		
200.93	287.75	530.03	624.73	558.48	73.56		380.93	4.35			
	1,421.00	16.20	295.01	135.76	161.32	307.10	211.94				
6.76		191.61	326.15	46.53	21.80		111.41	5.65	10.87		
			30.33	125.15	3.95		815.74		352.51		
	1,506.15	57.34	79.25	7.91	295.06	13.50	655.24	.70	18.75		
73.27		154.60	118.25	36.49	165.70		439.08	48.23	167.22		
198.23	4.60		143.60		19.60		9.55		57.03		
40.63		126.69	43.22	7.50			781.79		11.03		
94.79	492.88	6.12	56.15	12.29	275.75		310.21	1.63			
							723.48				
	334.22	1.26	205.42	235.73		105.50	228.05		232.35		
2,481.07	11,448.40	5,768.18	10,666.88	9,471.89	9,477.21	3,093.43	17,313.48	571.01	3,837.61		10.17

TABLE 5.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures						
		Salaries	Labor	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$15,000	$7,146.67	$1,957.63	$13.87	$78.82	$561.50	1,109.55	$86.73
Alaska	7,500	2,146.21	3,856.91		20.98		10.15	224.83
Arizona	15,000	9,919.69	2,580.30	32.42	53.81		442.48	713.51
Arkansas	15,000	9,480.00	2,312.95	107.06	1.40	324.97	967.69	354.78
California	15,000	14,164.45	835.55					
Colorado	15,000	15,000.00						
Connecticut:								
State	7,500	7,500.00						
Storrs	7,500	5,500.00	1,800.00	11.16	2.14			
Delaware	15,000	8,346.47	2,233.71		36.29		1,091.41	26.00
Florida	15,000	15,000.00						
Georgia	15,000	9,335.78	1,310.61	16.11	46.33	319.52	1,235.73	48.74
Hawaii	15,000	8,835.95	4,752.26	8.12	4.53		937.78	34.48
Idaho	15,000	11,577.30	1,631.24	3.71	.50	15.34	1,448.71	18.55
Illinois	15,000	6,798.00	8,201.31					
Indiana	15,000	13,045.00	592.75	16.33	2.09		249.02	
Iowa	15,000	15,000.00						
Kansas	15,000	10,300.00	3,421.95	16.35			312.78	26.45
Kentucky	15,000	14,079.04	109.18			7.16	640.32	31.09
Louisiana	15,000	10,914.99	1,786.64	35.35	52.65	67.08	565.56	190.66
Maine	15,000	12,208.17	1,742.13		42.86		393.07	127.46
Maryland	15,000	12,877.50	366.88	111.98	.50		499.85	23.93
Massachusetts	15,000	15,000.00						
Michigan	15,000	15,000.00						
Minnesota	15,000	15,000.00						
Mississippi	15,000	9,699.92	3,936.27	11.27	8.06	125.28	149.60	404.67
Missouri	15,000	4,405.32	4,427.27	30.94	71.35	64.33	732.80	497.95
Montana	15,000	12,488.94	534.95	5.68	4.30		458.47	54.29
Nebraska	15,000	15,000.00						
Nevada	15,000	10,643.50	3,137.57	93.84	11.97		302.21	160.29
New Hampshire	15,000	12,984.94	992.79	19.24	18.98	.18	191.78	104.12
New Jersey	15,000	11,206.50	424.19	26.78		711.40	1,367.83	127.98
New Mexico	15,000	9,187.46	3,461.47	62.33	149.64	334.75	960.28	85.67
New York:								
Cornell	13,500	12,963.34	533.16	1.65			1.85	
State	1,500	1,500.00						
North Carolina	15,000	11,724.00	1,060.68	5.45	31.91	12.00	663.36	120.59
North Dakota	15,000	12,765.52	598.21	192.91	8.27	225.75	407.97	15.00
Ohio	15,000	12,430.99		21.47	6.44		404.23	101.97
Oklahoma	15,000	6,075.28	1,968.88		9.10	27.57	740.84	52.98
Oregon	15,000	10,269.43	2,039.77	24.04	2.71	12.16	1,109.87	53.70
Pennsylvania	15,000	14,880.01	119.99					
Puerto Rico	15,000	6,568.06	2,001.08	34.60	30.80	1.26	120.14	667.95
Rhode Island	15,000	10,467.41	3,834.43		1.63		252.43	24.00
South Carolina	15,000	10,049.80	1,371.92	307.25	7.78	327.26	524.49	120.27
South Dakota	15,000	7,930.25	4,644.51	39.23	44.97		375.20	49.44
Tennessee	15,000	13,240.00	779.24	3.31	19.37	16.59	384.72	72.32
Texas	15,000	12,975.28	163.28				98.67	
Utah	15,000	9,500.24	3,213.20	25.33	41.48		726.18	169.18
Vermont	15,000	9,560.68	3,554.10	52.88	13.07	68.54	475.43	203.23
Virginia	15,000	9,753.66	2,285.46	.24	36.53	5.39	145.81	205.93
Washington	15,000	12,074.93	1,332.86	1.37			518.29	52.20
West Virginia	15,000	11,325.00	2,450.00	6.99	2.02	114.07	428.67	77.41
Wisconsin	15,000	14,069.28	930.72					
Wyoming	15,000	11,877.00	916.30	51.64	39.15		523.74	64.64
Total	757,500	571,791.96	90,204.30	1,391.10	905.43	3,342.10	21,968.96	4,892.72

the act of Mar. 16, 1906 (Adams Act) for the year ended June 30, 1938

Expenditures—Continued											
Fertilizers	Feeds	Library	Machinery, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
$38.40			$459.99	$2.24	$2,841.33	$225.00	$164.50	$1.42	$312.35		
6.20	$92.00				802.96	339.76					
6.65			105.28	7.50	571.94		1,064.92	1.50			
127.95	360.38	$17.26	217.96	41.20	300.52		385.88				
		98.26			88.44						
7.49		10.34	756.40	2.25	2,085.39		404.25				
	1,235.04	11.00	28.59		1,033.90	297.17	18.35	40.00	23.40		
32.70	132.66		8.37		204.45		33.90	14.80			
			48.55		174.28		62.22	9.60	10.00		
											$0.69
	164.08				822.13	85.00	23.60				
	673.79		8.45		218.21	9.56	12.46				
					108.50	9.75			14.96		
19.50	215.55	1.00	68.10	4.25	590.32	20.50	467.85				
		4.56	55.27	24.97	73.08		327.55		.88		
			13.62		1,090.26		15.48				
		3.22	624.97		34.25		2.49				
21.48	2,666.00		253.69		877.13	50.39	40.83	21.50	839.02		
		12.63	44.85	20.41	857.63		488.09	21.90	7.66		
	103.55	.80		41.90	112.90	119.45	144.92		127.10		
35.85	171.56		47.10		225.84		51.50		126.12	$30.00	
		60.02	26.43	54.01	707.06		8.58	40.94	238.28		
82.18		10.80	399.14		70.06		81.22	115.00			
45.72	18.25	3.75	16.82	2.79	732.21	26.50	535.97				
	409.90	11.31	17.81	17.90	232.57		94.31	.89			1.68
	1,499.35			276.13	125.00	117.25	17.17				
9.00	2,084.43		456.61	49.66	2,914.59		77.34		533.72		
68.40		3.75	43.50		957.93		414.74				
148.25			111.01		2,129.24		3,119.78				67.83
	371.59						48.51				
20.31		120.60	106.39	116.39	757.45	40.00	446.91	26.92	626.93	29.33	
		200.40	41.66	46.00	787.86		770.48			70.00	
10.79		36.88	30.45	17.38	195.98		54.05	1.50	137.42		
	289.25				191.30	1,195.05	76.10		11.07		
	20.02	5.42	132.63	152.65	501.13	56.00	449.92	9.62			
53.70		35.05	84.59	6.30	654.25		113.15		125.03		
81.96	1,539.39		57.61	78.56	351.80		342.42	9.55	70.69	35.00	
4.98		4.10	31.21	70.25	489.95		416.71		3.15		
73.20	351.61		37.44		127.61		3.00	2.98			
	403.97	7.17	11.27		288.65	295.70	318.02	3.00	199.75		
894.71	12,802.37	658.32	4,345.76	1,032.74	25,328.10	2,881.08	11,097.17	321.12	3,407.53	164.33	70.20

TABLE 6.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$60,000	$34,776.62	$8,389.92	$456.92	$285.78	$692.80	$1,338.14	$1,988.09	$748.05
Arizona	60,000	37,532.79	6,569.84	1,108.55	120.04	101.77	332.00	3,539.50	754.53
Arkansas	60,000	43,291.00	4,854.01	3,187.91	491.19	38.02	436.80	1,168.64	280.47
California	60,000	60,000.00							
Colorado	60,000	47,560.52	4,659.95	37.09	706.60	24.58	28.12	744.20	384.64
Connecticut:									
State	30,000	24,007.84	1,430.55	57.44	258.10	14.63	605.87	1,121.23	391.49
Storrs	30,000	21,068.89	4,186.13		1,239.61	32.64	54.58	540.95	349.14
Delaware	60,000	41,878.33	5,803.03	1,466.55	43.54	77.31	481.93	1,221.72	357.26
Florida	60,000	41,170.16	9,260.70		99.71		33.11	2,374.99	279.65
Georgia	60,000	28,767.90	16,390.56	8.28	153.93	398.82	2,573.13	1,052.22	882.37
Hawaii	20,000	12,691.38	5,310.86		50.87	2.65	4.85	448.80	300.67
Idaho	60,000	43,128.60	8,547.95	395.61	410.80	106.01	133.99	1,992.75	84.81
Illinois	60,000	34,316.46	12,008.17	1,469.92	1,208.56	91.16	34.90	2,444.32	19.95
Indiana	60,000	46,378.91	5,699.44	264.74	339.36	23.81	18.09	915.92	76.36
Iowa	60,000	59,511.50							
Kansas	60,000	37,500.00	18,339.69	29.69	67.22	11.79	28.73	1,932.21	199.98
Kentucky	60,000	48,047.07	5,168.89	1,301.46	125.60	11.53	8.82	903.77	133.13
Louisiana	60,000	42,335.85	9,440.89	380.00	332.38	119.71	176.12	512.38	662.31
Maine	60,000	40,679.68	6,242.31	5.00	20.43	69.19	653.35	1,220.33	764.68
Maryland	60,000	43,584.63	1,944.47	1,956.78	366.17	135.15	23.80	1,277.88	1,335.41
Massachusetts	60,000	51,877.74	1,631.66	590.64	90.48			1,070.96	131.54
Michigan	60,000	50,157.44	2,699.42	271.16	366.88	26.49		1,460.21	684.52
Minnesota	60,000	50,795.57	1,955.28	284.71	101.66	211.99		1,326.57	108.35
Mississippi	60,000	36,510.63	7,739.73	983.90	790.22	346.86	1,964.44	853.40	1,039.99
Missouri	60,000	21,872.25	18,639.91	3,291.85	203.97	387.99	357.35	3,732.97	912.74
Montana	60,000	41,121.50	11,043.27	1,526.32	50.98	71.30	123.59	895.94	500.13
Nebraska	60,000	43,149.19	8,865.69	1,208.93	175.60	27.98	1.19	1,062.06	173.71
Nevada	60,000	31,578.00	13,324.12	250.65	1,236.62	149.47	468.78	716.05	1,316.39
New Hampshire	60,000	44,147.90	6,760.00	924.77	246.59	98.83	55.47	820.96	638.64
New Jersey	60,000	52,097.15	1,216.72	226.95	401.23		129.66	992.85	402.31
New Mexico	60,000	31,504.27	10,959.11	1,187.00	880.96	332.97	435.97	1,205.19	538.44
New York:									
Cornell	54,000	37,192.00	7,602.30		444.55	22.41		610.39	16.87
State	6,000	5,945.84	54.16						
North Carolina	60,000	40,992.22	8,969.49	984.64	453.06	101.72	38.71	472.18	303.82
North Dakota	60,000	38,214.33	5,530.74	60.08	564.35	506.40	626.00	968.25	234.51
Ohio	60,000	48,698.32	72.31	55.97	9.17	11.87	516.88	499.13	234.96
Oklahoma	60,000	31,801.35	13,971.61	247.66	645.39	45.29	2.12	1,182.38	288.82
Oregon	60,000	37,386.18	10,826.24	839.65	871.95	43.12	120.45	2,943.63	156.19
Pennsylvania	60,000	44,559.34	4,142.86	153.35	343.58	44.93	126.00	1,997.34	202.55
Puerto Rico	10,000	5,899.99	1,793.73	286.03	189.95			10.00	4.00
Rhode Island	60,000	40,129.40	9,247.30	331.01	26.89	20.50	790.83	1,128.40	197.02
South Carolina	60,000	41,380.94	9,035.79	1,467.77	801.12	64.31	178.81	750.67	188.50
South Dakota	60,000	30,060.44	12,158.58	4,441.04	823.87	184.32	25.53	1,971.75	1,372.41
Tennessee	60,000	46,506.95	6,709.65	80.99	512.57	143.62	514.55	784.12	555.69
Texas	60,000	41,264.17	12,382.14		574.64	115.88	65.19	1,201.84	97.49
Utah	60,000	37,408.31	14,776.85	87.71	478.47	37.79	48.94	803.88	684.43
Vermont	60,000	36,247.06	10,030.05	559.89	644.71	99.01	1,567.14	1,945.08	733.73
Virginia	60,000	40,418.15	11,745.33	1,107.52	594.87	.95	338.81	409.25	220.56
Washington	60,000	41,000.39	9,001.16	485.99	160.49	2.20		1,172.41	790.66
West Virginia	60,000	36,466.84	10,278.63	647.67	24.61	17.82	429.54	1,140.26	784.21
Wisconsin	60,000	53,087.15	5,197.09		52.49	15.04	8.49	245.09	
Wyoming	60,000	35,529.34	5,391.33	1,130.16	217.64	105.22	81.80	1,399.91	382.57
Total	2,910,000	2,013,228.48	387,999.61	35,839.95	19,299.45	5,187.85	15,982.57	61,173.02	21,900.65

the act of Feb. 24, 1925 (Purnell Act), for the year ended June 30, 1938

Expenditures—Continued

Fertilizers	Feeds	Library	Machinery, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
$76.80	$3,846.67	$56.89	$276.48	$389.41	$4,125.99	$7.31	$1,007.05	$47.40	$1,489.68		
540.55	984.52	8.23	1,123.33	1,024.75	3,851.79	71.82	2,138.99	28.00	169.00		
30.00	111.70	152.56	42.95	623.14	1,375.78		1,628.13	21.20	2,130.38	$136.12	
133.29	581.85	158.97	385.02	164.57	1,896.96	51.79	2,203.96	3.33	274.56		
85.51		118.08	657.98	15.59	615.01		422.04	93.07	105.57		
96.98		74.09	318.26	51.46	750.05	42.77	1,070.73	56.05			$67.67
228.75	3,053.27	204.71	569.33	383.41	986.45	96.00	2,619.99	108.00	270.42	150.00	
166.48	920.39	25.59	101.22	46.30	2,555.37	110.38	2,510.41	343.00	2.54		
432.03	3,202.96	255.45	2,466.74	221.99	1,126.42	60.00	1,543.89	74.08	389.23		
106.37	14.30	3.31	38.50		745.04		182.40	100.00			
	1,304.01	54.08	214.71	252.42	1,067.70	60.00	1,942.90	130.46	73.20	100.00	
		34.64	1,568.78	456.36	2,554.49		3,001.83	140.46	650.00		
	14.94	15.50	262.69	393.05	951.29		4,546.91	47.99	51.00		
					488.50						
	484.14	54.21	444.21	45.28	588.82	39.69	208.80	13.99	11.55		
6.25	890.31		6.00	62.95	792.29	150.00	2,373.65		18.28		
337.29	1,314.46	23.76	1,865.42	94.69	307.44	116.67	1,799.86	92.84	87.93		
2,109.66	1,268.35	22.57	3,191.95	26.69	1,457.52	221.00	1,978.59		68.70		
307.91	44.19	22.74	1,304.02	2,130.33	1,767.62	115.00	2,886.60		757.00	40.00	
	860.23	195.70	138.36	330.76	2,087.66	218.11	755.28	20.88			
	558.22	38.19	414.42	307.17	1,464.52		1,511.79	39.57			
	1,030.04	12.90	392.00	129.24	2,407.80	150.00	1,078.14	15.75			
331.22	1,745.84	80.17	3,302.18	675.48	2,165.64		999.21	35.17	435.92		
6.20	4,887.47		988.24	706.75	2,054.20	500.00	955.94	89.73	312.44	100.00	
5.75	847.00	35.00	988.32	167.46	450.87	12.50	2,003.39	31.04	125.64		
	1,122.14	68.54	386.10	221.71	1,388.85	962.75	633.11		552.45		
	2,382.85	49.11	636.74	1,100.10	886.74	2,623.00	2,720.27	137.58	1,023.53		
554.34	549.17	18.00	510.75	154.45	998.44	21.00	2,866.49	10.45	237.75	386.00	
32.66	21.60	122.89	1,294.70	216.01	1,644.59	22.75	917.84	142.51	117.58		
56.69	2,262.21	45.84	1,271.68	3,062.05	1,543.70	1,264.38	2,802.71	273.23	211.60	162.00	
		59.50	474.97	407.45	5,813.77		1,337.79	18.00			
107.11	3,644.22	9.39	57.90	53.50	1,126.38		2,463.94	1.24	220.48		
3.50	8,401.04	137.17	671.15	466.97	2,363.24	109.95	931.67	159.03	51.34		.28
	6,493.78		185.43		789.89	931.94	480.47		1,019.88		
25.00	6,489.30		1,116.21	705.21	2,467.85	85.09	861.17	37.25	28.30		
17.49	591.25	59.93	1,253.09	725.40	529.20		2,802.18	124.76	675.24	34.05	
39.40	2,482.83		376.63	87.57	3,333.32	393.38	1,716.92				
							1,162.66				653.64
70.00	4,204.60	110.91	1,306.41	183.50	1,094.43		674.03		484.77		
439.50	1,778.10	181.42	394.75	218.84	1,586.78	150.00	1,311.14	19.95	51.61		
	1,084.35	202.46	416.87	1,080.49	3,508.81	125.00	2,356.58	1.82	185.68		
98.78	357.59	72.09	1,136.48	537.12	398.17		999.27	30.40	456.96	105.00	
19.75	609.21	85.00	722.64	47.18	1,075.37	71.90	1,159.52	24.18	453.90	30.00	
	10.90	161.43	1,344.28	274.05	569.51		2,167.26	82.44	15.00	1,048.75	
6.00	1,144.23	56.15	544.94	333.34	2,435.93	96.00	1,938.73	122.60	1,495.41		
	60.12	16.32	697.29	163.34	2,292.28	8.80	1,871.97		54.44		
159.93	2,193.43	115.69	886.76	394.88	1,289.23	70.00	2,099.30	5.00	172.48		
480.45	1,880.20	22.52	1,544.36	230.42	654.25	666.00	1,967.22		365.00	2,400.00	
	286.46				305.39		802.80				
	9,433.99	76.67	253.13	106.08	2,346.86	586.02	2,751.37	98.70	79.21	30.00	
7,111.64	85,448.73	3,318.37	38,544.37	19,468.91	79,078.20	9,611.00	83,166.89	2,821.15	15,375.65	4,721.92	721.59

TABLE 7.—*Expenditures from Federal appropriations received under the*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$62,021.34	$33,723.60	$5,260.47	$2.00	$26.22	$1,705.56	$1,021.43	$1,731.04	$832.54
Alaska	1,677.36					48.97			
Arizona	9,316.92	5,990.72	705.48		82.46	10.25	9.18	244.25	219.71
Arkansas	47,987.40	32,940.81	4,471.31		604.56	2.14	213.07	1,652.44	391.63
California	49,456.47	49,455.47			1.00				
Colorado	16,823.22	11,444.39	2,005.39		315.86	2.16		126.30	16.26
Connecticut:									
State	7,746.78	5,984.83			114.84	.86	556.65	481.16	26.84
Storrs	7,746.78	5,198.16	1,430.18		42.50		25.80	232.11	7.94
Delaware	3,757.65	3,000.00	18.30			8.78		264.31	1.26
Florida	23,101.23	5,383.34	8,960.62			20.31	276.97	698.68	1,481.81
Georgia	65,642.19	33,034.21	12,080.56	316.94	203.64	170.00	1,985.71	1,062.32	730.85
Hawaii	6,889.80	3,330.00	1,242.60		13.40	.25		606.09	23.89
Idaho	10,288.92	5,613.94	1,919.12	10.90	42.20	18.02		123.14	14.23
Illinois	65,052.39	26,834.01	15,050.69	800.00	409.30	213.72	793.02	2,903.65	864.40
Indiana	47,041.95	20,757.33	4,846.15	12.00	23.02	66.59		2,404.10	168.60
Iowa	48,640.98	38,614.67		489.04					
Kansas	37,538.22	14,800.00	4,181.22	119.00	14.60			761.01	187.31
Kentucky	59,203.53	39,620.10	2,318.67	293.90	5.60	5.13		399.09	360.85
Louisiana	41,350.08	29,387.16	5,860.24	11.13	194.74	77.89	127.33	1,269.53	517.18
Maine	15,519.12	10,572.97	2,172.21			46.82		527.40	218.73
Maryland	21,412.86	14,162.08	1,370.74	52.20	273.96	1.66		475.56	319.91
Massachusetts	13,636.65	13,636.65							
Michigan	50,225.88	31,194.90	4,738.83	29.34	21.67	57.17	105.76	1,704.00	484.92
Minnesota	42,598.23	27,810.62	3,298.27	354.05	46.04	154.31		1,611.24	638.53
Mississippi	54,488.55	21,850.40	9,943.66	49.40	334.79	547.19	757.89	854.82	1,249.40
Missouri	57,725.85	17,634.58	13,262.75	3,042.31	343.73	405.02	738.75	4,337.02	1,182.92
Montana	11,627.37	8,297.29	3,022.50		10.86	2.94		109.32	29.63
Nebraska	29,082.45	20,285.09	3,645.12	3.85				459.23	73.32
Nevada	1,845.48	1,425.00	4.00		38.72	1.34		12.04	30.01
New Hampshire	6,267.90	4,010.00	1,689.03	42.87	.90		.56	9.29	1.65
New Jersey	22,894.38	18,515.79	1,512.79	31.30	48.91	1.02	339.38	413.07	200.02
New Mexico	10,320.75	4,600.85	2,463.49		67.48	32.14	150.91	129.22	394.96
New York:									
Cornell	60,636.36	44,185.54	4,967.12		141.50	92.70	62.09	2,908.48	248.50
State	6,737.37	3,866.88	672.87		6.11			1,364.40	10.50
North Carolina	76,971.00	49,234.26	6,218.25	36.47	134.58	341.36	261.47	2,795.82	1,478.65
North Dakota	18,506.82	13,160.29	2,040.30	18.90	158.37	32.66	74.92	431.74	50.46
Ohio	69,761.07	51,519.93	32.40	297.82	6.74	31.52	570.22	467.21	433.02
Oklahoma	51,338.13	14,556.80	8,573.67	247.67	241.61	102.41	85.26	1,372.63	1,003.18
Oregon	15,131.85	10,810.26	2,877.16		101.56	15.18	25.24	302.30	59.36
Pennsylvania	101,017.14	71,113.74	8,646.19	982.01	91.97	158.93	258.84	2,698.85	1,781.99
Puerto Rico	36,414.12	14,075.00	7,779.14		143.68			1,185.85	1,156.64
Rhode Island	1,697.88	1,697.88							
South Carolina	44,598.72	18,191.06	3,864.90		153.98	108.39	509.40	909.49	655.00
South Dakota	18,324.33	5,496.61	4,635.89		55.86	103.95	21.55	314.91	325.17
Tennessee	56,087.91	21,521.60	11,626.68		199.14	186.35	230.97	59.02	1,082.89
Texas	112,023.57	64,445.99	19,419.46		256.36	18.76	162.84	3,182.70	675.86
Utah	7,877.76	4,174.96	2,317.59		82.07	4.44		134.42	119.65
Vermont	7,853.70	6,036.22	1,521.95		3.29	1.47	73.01	15.00	62.60
Virginia	53,358.42	26,453.16	9,008.95	22.91	102.39	63.44	569.14	2,008.66	1,056.05
Washington	22,136.79	14,807.97	3,622.29		50.38	3.85		643.63	172.79
West Virginia	40,360.08	20,599.56	6,815.99	121.27	87.10	40.96	122.06	1,537.74	441.11
Wisconsin	45,168.66	39,728.51	4,861.23		8.05	.50		39.30	
Wyoming	5,069.64	3,947.00	48.65	200.00	32.00	10.79		53.02	
Total	1,800,000.00	1,058,732.18	227,025.07	7,587.28	5,337.74	4,917.90	10,129.42	48,026.60	21,482.72

act of June 29, 1935 (Bankhead-Jones Act) for the year ended June 30, 1938

Expenditures—Continued											
Fertilizers	Feeds	Library	Machinery, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
$203.73	$4,862.42	$45.85	$1,518.79	$339.48	$1,842.40	$10.00	$1,561.67	$68.41	$7,265.73		
						1,475.53					$152.86
	40.28	25.00	363.82	132.82	491.16		1,046.79	15.00	27.00		
	363.44	38.45	341.34	708.56	3,340.88	170.25	2,608.47		140.05		
			979.87	82.15	167.55		1,668.86		14.43		
			8.69	48.35	429.94		99.40	4.22			
152.60		10.21			323.40		295.00				28.88
		83.42	2.60		347.18		31.80				
608.67	51.00		573.96		357.83	901.57	1,466.15		2,320.32		
185.39	1,799.84	117.55	2,250.16	268.20	1,050.29	980.16	2,336.12	130.00	2,940.25	$4,000.00	
8.15	2.88	6.00	25.00		1,174.70		1.69	10.50	444.74		
	1,362.25	3.40	23.40		170.72		722.50	2.60	22.50	240.00	
		21.64	1,990.27	1,272.12	10,371.48	1,207.70	1,682.12	52.44	585.83		
22.50	761.51		1,562.85	709.13	9,136.86		1,891.12	60.00	4,620.19		
						175.00			9,362.27		
3.75	1,719.44	1.49	366.35	61.78	486.75	480.00	122.29	4.00	14,229.23		
46.35	496.03		151.36	25.80	4,544.99	11.00	1,445.66	10.56	9,468.44		
208.40	873.27	5.28	745.03	343.45	655.90	139.18	823.35	29.34	81.68		
121.97	568.19	12.90	304.30		217.83	100.00	655.80				
312.69	2.70		90.38	14.00	2,530.88		1,415.60		20.50	370.00	
218.07	641.56	21.59	746.14	798.49	6,944.41		838.14	9.75	1,671.14		
59.50	496.16	4.50	332.34	378.09	3,756.17	323.80	1,681.16	5.00	988.45	660.00	
184.06	3,635.57	52.44	3,727.41	482.59	2,273.04	99.80	1,143.14	139.52	744.43	6,419.00	
64.87	2,792.15		1,359.96	399.19	2,228.89	974.50	1,963.15	49.57	1,336.49	4,700.00	
	9.00		1.21	22.00	3.25		119.37				
		4.98			3,140.40		196.34		2,274.12		
		4.45		4.50	31.50		293.92				
		1.60					512.03				
	277.73	17.20	184.23	64.52	186.81	104.25	782.99	65.50	148.87		
	526.71	6.19	875.74		192.42	400.60	208.16	15.00	12.84	244.73	
	1,555.84	7.50	459.56	302.36	3,005.60	63.00	2,032.70	6.60	597.27		
		20.14			581.50		214.97				
549.39		17.98	641.16	280.84	3,557.02		4,755.66	5.01	6,505.49	157.59	
	209.08	72.73	289.52	206.55	1,108.35	132.02	505.75	2.12	6.75		6.26
39.76	959.31	19.38	1,424.69	217.19	5,764.00	6,147.43	258.88		1,191.57	380.00	
25.00	5,104.48	29.00	1,545.83	194.73	1,906.14	210.00	112.51		16,027.21		
	15.50		93.50		401.33		430.12	.34			
530.01	3,318.89		4,015.98	507.10	2,804.65	391.50	3,632.92	4.00	79.57		
403.48	128.30		2,274.16	193.97	4,174.84	50.00	2,669.51		39.25		2,140.30
795.38	862.55	153.69	1,258.34	117.51	1,590.44	9.45	940.15	56.22	14,387.77	35.00	
	2,315.04	9.93	78.84	46.35	749.47	425.00	237.15	8.56		3,500.00	
438.59	131.64	8.85	609.04	27.53	297.00	4,781.64	673.10	204.38	14,009.49		
7.35	6,114.42	133.34	835.33	688.46	3,818.04	1,596.88	2,491.71	2.35	8,158.72	15.00	
		5.00	42.80	102.60	8.58		885.65				
	2.25		115.96	1.62	1.50			6.98	11.85		
233.82	179.77	49.92	2,190.61	1,795.43	4,613.33	7.42	1,771.58	21.53	3,180.31		
12.30	188.30	4.00	707.52	125.71	194.33	259.00	1,317.70	1.36	25.66		
24.80	845.75	13.33	147.42		929.50	11.76	1,253.25	225.33	1,543.15	5,600.00	
22.30					2.10		436.67			70.00	
		41.91	484.86		22.50		228.91				
5,512.88	43,213.25	1,070.85	35,740.32	10,873.17	91,831.85	21,637.81	52,461.56	1,216.19	124,483.56	26,391.32	2,328.30

TABLE 8.—*Expenditures from supplementary funds received from within the States for the year ended June 30, 1938*

Station	Salaries	Labor	Publications	Postage, stationery, telegraph, and telephone	Freight, express, and parcel post	Heat, light, water, power, and fuel	Chemical supplies	Seeds, plants, and sundry supplies	Fertilizers	Feeds
Alabama	$70,365.25	$46,762.44	$6,989.28	$2,330.01	$4,326.81	$6,805.44	$1,002.57	$7,735.44	$7,935.37	$9,960.85
Alaska	2,381.94	3,245.49		62.26	784.45	810.62	27.30	496.80	70.20	151.00
Arizona	55,223.92	23,970.58	4,430.73	1,772.53	200.76	2,501.19	1,843.04	3,104.69	689.75	5,300.51
Arkansas	54,461.56	20,884.28	401.56	3,241.83	1,722.98	4,678.03	8,499.71	42.08		2,805.82
California	478,190.52	191,276.21	23,909.53	21,518.58	7,172.86	25,105.00	22,714.05	43,037.15	8,368.33	53,796.43
Colorado	59,049.48	22,835.18	3,290.26	2,789.51	1,222.83	6,773.40	1,442.66	3,223.08	115.79	2,670.76
Connecticut:										
State	173,870.42	38,242.37	389.46	3,404.02	76.83	5,308.03	2,596.78	2,159.37	1,267.68	553.61
Storrs	30,477.85	8,459.06	328.15	1,142.36	391.87	557.46	2,177.68	1,280.97	275.87	2,898.65
Delaware	4,742.63	15,656.21		715.18	183.16	2,955.18	57.79	3,620.23	434.10	5,916.53
Florida	199,596.29	94,740.78	6,336.66	7,753.72	1,994.92	13,920.73	6,962.87	11,591.05	10,602.25	17,970.17
Georgia	26,636.21	21,750.05	94.25	1,280.36	960.80	5,727.36	669.79	5,082.02	13.22	4,207.06
Hawaii	21,205.40	8,482.14	788.34	1,612.34	420.36	2,816.39	1,718.36	3,255.80	633.08	4,069.80
Idaho	20,146.00	8,058.40	1,007.30	906.57	302.19	1,057.67	956.94	1,813.14	352.56	2,266.43
Illinois	231,129.70	91,101.10	10,192.08	7,048.81			14,310.73	27,115.01	5,272.41	33,893.75
Indiana	259,977.58	113,508.28	6,207.51	42,413.91	2,773.79	11,237.23	47,384.02	7,876.95	2,594.23	33,789.67
Iowa	154,912.98	38,034.24	14,099.02	4,646.22	1,378.77	1,414.30	5,825.96	18,357.57	149.53	10,016.59
Kansas	40,216.57	57,916.51	1,973.21	3,374.99	2,054.03	6,479.22	3,072.32	10,199.67	418.83	11,927.36
Kentucky	139,407.96	43,538.25	881.53	10,717.75	1,162.42	8,965.58	1,593.12	14,953.20	980.68	10,840.35
Louisiana	47,503.00	30,584.74	535.03	2,283.02	741.44	4,077.44	2,401.85	3,684.57	1,726.17	1,953.30
Maine	28,146.53	17,554.44	9.14	651.51	686.36	3,957.90	1,508.76	1,521.56	90.38	577.83
Maryland	33,672.77	27,509.29	4,656.71	777.62	1,741.63	1,268.55	1,246.65	2,470.65	1,601.22	9,642.74
Massachusetts	137,512.78	36,899.91	3,258.90	2,474.83	1,366.64	1,261.10	6,249.00	3,643.62	873.84	5,429.11
Michigan	146,652.48	55,876.71	15,861.62	3,423.49	738.51	2,753.97	5,953.91	6,765.92	520.25	13,377.33
Minnesota	220,527.92	88,211.17	4,764.32	8,868.79	1,434.77	15,991.52	19,264.05	7,797.21		18,935.30
Mississippi	61,738.19	42,401.03	999.74	2,919.92	932.85	5,224.79	482.41	9,981.87	3,505.50	4,498.67
Missouri	43,974.55	51,911.00	7,255.48	3,188.28	1,207.25	972.92	5,358.66	13,680.34	1,897.93	11,563.78
Montana	55,456.62	14,167.47	3,138.99	3,077.06	625.30	2,910.75	949.86	9,203.94	213.73	14,044.45
Nebraska	67,790.55	28,829.31	3,353.64	3,236.50	1,219.62	8,013.49	8,325.19	2,683.90	4,835.69	44,194.16
Nevada	465.00	1,485.50	9.85	295.27	44.38	2,098.64	114.50	162.94		
New Hampshire	21,766.00	5,365.81	282.38	920.91	272.58	21.38	2,227.65	1,345.60	2.16	254.94
New Jersey	353,405.01	15,866.67	6,467.93	11,709.01	1,347.22	16,047.65	11,099.93	878.47	1,689.65	29,707.87
New Mexico	11,064.37	5,717.27	114.47	579.45	281.80	409.45	292.66	1,689.66	82.35	5,361.98
New York:										
Cornell	438,357.06	70,765.70	16,678.30	9,858.26	1,740.04	23,646.98	21,147.78	18,529.46	3,602.92	16,800.37
State	170,016.62	31,499.76	6,463.96	5,229.39	453.95	11,999.46	4,123.98	6,122.92	900.00	3,563.04
North Carolina	43,624.51	17,751.02	862.96	937.30	171.39	564.39	275.85	1,668.77	1,599.36	9,634.38
North Dakota	15,274.05	8,907.55	954.11	721.00	6,418.82	18,825.38	1,452.61	1,522.11		16,583.63
Ohio	209,577.63	127,112.65	22,808.05	5,550.67	2,707.85	11,652.05	1,472.50	34,570.29	963.81	32,737.28
Oklahoma	143,605.50	12,311.81	9,017.27	2,232.97	788.80	1,582.23	4,527.83	3,229.99	115.60	8,973.42
Oregon	123,597.70	94,069.19	2,960.31	4,060.44	1,735.85	7,460.57	8,989.48	16,000.37	618.21	11,493.23
Pennsylvania	83,451.66	36,224.21	2,681.67	4,931.10	1,643.70		5,205.05	9,863.16	1,917.65	12,327.75
Puerto Rico	79,923.73	23,240.81	3,037.39	1,899.55	260.32	2,383.40	1,186.79	3,804.27	1,786.51	1,768.00

Rhode Island	1,242.87	3,785.96	41.90	234.60	49.34	284.32	89.78	592.32		136.59
South Carolina	38,447.65	47,257.16	477.74	2,270.04	1,337.14	1,822.31	11,831.48	7,200.59	5,708.11	12,462.42
South Dakota	11,135.00	7,658.77	760.00	400.78	94.81	458.87	180.25	1,336.09		5,473.61
Tennessee	24,598.99	10,301.03	1,026.70	1,148.57	532.38	2,317.19	194.12	1,848.68	378.29	5,077.45
Texas	258,273.42	100,223.12	12,505.23	11,497.72	1,140.52	9,291.19	7,119.92	39,796.07		25,606.35
Utah	21,463.95	15,518.64	834.37	2,359.71	469.67	431.01	472.23	2,132.86	191.00	1,868.63
Vermont	13,142.19	4,013.05	1,274.63	364.55	86.13	680.38	338.04	298.89		4,246.74
Virginia	54,541.60	17,058.73	1,967.79	2,295.69	782.13	1,091.61	1,448.08	1,441.94	896.35	2,457.57
Washington	60,143.07	59,933.29	2,439.66	2,682.61	1,168.41	6,574.67	6,451.63	6,011.52	775.05	10,538.22
West Virginia	34,057.19	20,327.92	354.18	1,276.65	110.91	5,405.29	965.21	6,180.94	1,225.96	12,980.31
Wisconsin	308,843.25	28,575.07	6,115.24	4,688.97		2,397.40	5,734.38	29,855.10	1,602.28	21,501.99
Wyoming	42,601.46			651.78	651.78	2,082.59		4,248.12		6,744.18
Total	5,427,587.13	2,013,377.33	225,288.53	226,428.96	62,114.12	283,073.67	271,539.19	426,708.93	79,493.85	595,461.96

Station	Library	Machinery, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance	Total
Alabama	$460.83	$12,046.97	$1,823.96	$2,820.36	$11,237.41	$10,598.92	$13,462.96	$27,361.58	$16,582.67	$145,180.78	$405,789.90
Alaska	6.40	1,097.60	262.78	5.50	2,126.50	153.87	2,523.95	1,073.61		2,480.99	17,761.26
Arizona	7.20	2,069.11	4,617.13			5,514.29	869.03	2,992.38	60.00	917.99	116,084.83
Arkansas	771.10	3,814.52	620.09	2,400.15	2,191.42	6,077.71	1,418.30	31,120.69			145,151.83
California	4,781.91	28,691.44	8,368.33	14,345.72	17,932.14	41,841.67	15,541.19	63,360.24	17,932.14	107,592.87	1,195,476.31
Colorado	313.92	5,733.36	207.91	1,827.36	3,587.17	5,920.62	242.70	10,445.33	341.90	12,770.09	144,802.71
Connecticut:											
State	1,389.95	3,492.01	1,182.92	1,181.13	269.40	12,646.33	2,068.57	2,026.64			252,125.52
Storrs	235.19		1.59	100.52	197.00	682.92	156.76			1,016.12	50,380.02
Delaware	16.09	1,911.19	71.45			232.94		4,305.57		3,266.22	44,084.47
Florida	3,348.60	12,284.54	3,696.66	10,526.94	4,352.38	20,847.38	3,239.42	24,478.44	30.00	33,554.06	487,827.86
Georgia	475.40	3,598.83	1,142.05	165.95	3,572.33	3,540.67	4,037.76	11,560.66	1,550.00	5,736.31	101,801.08
Hawaii	166.87	1,000.67	291.94	500.39	625.47	1,342.12	5,354.64	4,446.30	6,872.99		65,603.40
Idaho	201.46	1,208.76	352.56	604.38	755.48	1,762.78	654.75	2,669.81	755.48	6,986.80	52,819.46
Illinois	1,382.84	8,297.05	2,419.97	4,148.53	5,185.65	13,867.53	6,111.79				461,476.95
Indiana	3,053.75	16,042.10	5,496.38	7,212.18	1,052.60	25,609.15	8,404.74	102,729.39	16,655.00	319,305.40	1,033,323.86
Iowa		6,534.20	12.80	4,372.17	6,769.98	9,708.44	3,014.56	2,833.80	15,042.17	17,467.59	314,590.89
Kansas	274.05	13,698.61	1,657.86	1,821.93	3,160.80	4,967.10	626.15	6,806.43	1,983.00	32,187.73	204,816.37
Kentucky	2,551.47	5,960.54	1,326.19	720.37	2,594.21	12,297.70	5,412.64	34,859.42	312.50	10,292.49	315,368.37
Louisiana	227.76	6,755.88	1,830.05	1,192.98	1,203.73	5,425.35	753.60	3,331.32	249.08	2,420.98	118,881.29
Maine	270.00	2,629.47	325.49	2,490.59	124.15	2,256.20	564.54	1,336.99	358.81		65,060.65
Maryland	391.56	3,239.71	527.40	580.95	2,915.43	2,563.99	6,146.91	5,463.39	1,175.00	29,389.48	136,981.65
Massachusetts	1,110.60	2,412.48	1,128.67	2,350.72	274.38	7,435.19	330.36	633.75	108.03		214,753.91
Michigan	1,286.40	6,503.67	1,423.70	5,958.40	2,822.42	9,015.93	1,375.06	1,409.87	250.00		281,969.64
Minnesota	2,488.71	13,900.62	2,712.21	3,526.22	6,023.01	7,992.54	9,963.00	19,719.72	845.45		452,966.53
Mississippi	166.86	28,023.08	1,135.30	1,029.87	668.44	4,173.35	4,270.31	58,541.27	1,560.00	2,816.89	235,070.34
Missouri	345.76	13,344.38	3,173.79	6,772.53	3,357.95	5,948.81	1,422.16	8,353.71	2,420.00	33,112.76	219,262.07
Montana	248.43	5,810.48	625.35	201.97	1,657.50	2,669.99	95.00	1,938.62	552.50	18,861.03	136,449.04
Nebraska	236.73	12,134.12	1,254.70	4,963.68	15,106.21	2,576.29	760.06	4,549.59	239.00		214,212.43
Nevada	475.91		167.90	15.34	100.00	1,672.04	857.23	1,005.74		8,572.02	17,542.26
New Hampshire	41.06	612.39	857.14	1,162.86		2,313.48	594.70	3,559.10		9,712.29	51,312.43

TABLE 8.—*Expenditures from supplementary funds received from within the States for the year ended June 30, 1938*—Continued

Station	Library	Machinery, etc.	Furniture, fixtures, etc.	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance	Total
New Jersey	$1,196.97	$18,162.13	$2,376.03	$2,248.98	$1,297.00	$14,322.42	$13,953.84	$3,252.90		$7,060.32	$512,090.00
New Mexico	28.29	966.52	199.74	323.32	250.00	502.14	809.94	891.14	$250.00	35,742.00	65,556.55
New York:											
Cornell	2,397.54	10,379.71	13,472.76	18,304.14	2,722.23	27,120.48	4,664.97	9,055.77			709,244.47
State	1,818.53	288.19				2,780.50	1,005.31	7,000.60	2,730.40		255,996.01
North Carolina	12.50	3,454.56	600.55	435.26	1,440.70	4,016.95	4,614.11	3,218.60	20,389.18		115,272.34
North Dakota	102.98	8,616.69	1,027.23	1,251.85	724.01	1,286.73	1,944.03	3,067.57		49 930.58	138,610.93
Ohio	857.37	15,200.55	32.78	552.68	7,557.30	5,753.84	3,271.11	5,463.77	23,303.98	320,703.76	831,849.92
Oklahoma	758.09	13,361.54	1,840.42	4,345.92	20,229.64	8,224.21	1,396.06	81,410.89	2,492.00	45,461.35	365,905.54
Oregon	260.20	5,254.02	1,215.60	5,221.64	13,670.15	13,386.02	5,278.32	1,835.39	5,372.53	107,550.45	430,029.67
Pennsylvania	324.76	1,948.56	568.33	974.28	1,217.85	9,588.25		4,303.19	1,217.85	2,787.95	181,176.97
Puerto Rico	877.39	1,945.88	789.88	669.18		2,633.74	2,987.74	7,635.36		4,146.74	140,976.68
Rhode Island	53.59	310.12	16.85	750.46		122.65	113.53	1,426.48		2,123.78	11,375.14
South Carolina	335.91	8,019.21	907.66	7,790.21	5,812.00	3,576.59		34,361.73	8,542.01	8,295.08	206,455.04
South Dakota	61.35	582.51	113.31	1,165.67	9,489.47	691.67	52.05	1,661.02	6,985.00	12,178.68	60,478.91
Tennessee	201.85	2,369.43	319.15	103.43	5,690.88	936.78	3,494.80	8,932.24			69,471.96
Texas	11,169.97	13,869.81	3,228.45	7,111.13	22,255.61	24,589.22	56,015.03	34,925.69	20,187.47	97,431.86	756,237.78
Utah	1,054.65	1,046.91	698.62	528.20	356.30	3,224.83	532.97	506.97	6,955.82	1,824.87	62,472.21
Vermont	57.37	182.58	13.16	230.51		1,725.77	315.31	368.34		517.98	27,855.62
Virginia	1,301.57	1,618.29	573.90	666.52	550.20	6,228.76	1,219.27	3,335.56	1,579.29	17.24	101,082.09
Washington	884.59	15,612.70	2,142.00	3,832.26	1,100.05	5,954.92	1,745.39	10,045.63	30,307.50		228,343.17
West Virginia	16.50	4,040.67		1,351.19	898.50	1,934.39	886.53		1,150.00	3,364.08	96,526.42
Wisconsin	200.00	6,162.38	2,487.98	15,883.43	477.19	9,060.29	1,212.02	10,750.36	1,445.75		456,993.08
Wyoming		1,247.54	635.64		1,261.12	1,081.42	310.99	1,434.92	684.27	34,751.21	98,387.02
Total	50,698.78	357,488.28	81,974.31	156,739.95	196,873.36	380,397.87	206,096.16	677,796.88	219,468.77	1,537,528.82	13,476,134.85

TABLE 9.—*Experiment station expenditures for additions to equipment for the year ended June 30, 1938*

Station	Buildings	Library	Apparatus	Farm implements	Livestock	Total
Alabama	$17,780.90	$946.89	$10,406.33	$14,246.87	$11,479.72	$54,860.71
Alaska	16.71	6.40	808.46	1,104.40	3,966.79	5,902.76
Arizona	1,054.96	40.43	4,684.91	3,441.23	71.82	9,293.35
Arkansas	26,733.62	1,005.45	7,620.22	4,596.26	2,411.67	42,367.22
California	63,360.24	4,781.91	14,345.72	28,691.44	17,932.14	129,111.45
Colorado		472.89	3,641.37	6,654.99	3,638.96	14,408.21
Connecticut:						
State		1,508.03	2,082.61	4,051.12	269.40	7,911.16
Storrs		997.15	1,847.61	517.98	239.77	3,602.51
Delaware	100.00	1,056.07	3,057.50	3,195.37	183.48	7,592.42
Florida	6,102.81	3,374.19	13,140.96	12,728.65	5,364.33	40,710.94
Georgia	5,238.32	1,090.07	2,663.67	6,873.20	5,034.66	20,899.92
Hawaii	4,891.04	198.83	3,662.53	1,072.54	625.47	10,450.41
Idaho	2,695.04	287.40	2,040.43	1,243.45	815.48	7,081.80
Illinois	225.27	1,439.12	16,395.99	11,789.42	6,393.35	36,243.15
Indiana	88,943.95	3,069.25	17,987.21	17,789.93	1,137.60	128,927.94
Iowa	12,146.07		4,860.67	6,534.20	6,944.98	30,485.92
Kansas	14,401.46	358.07	3,162.67	14,295.47	3,690.05	35,907.72
Kentucky	30,122.63	2,569.92	6,081.86	6,076.70	2,764.96	47,616.07
Louisiana	687.56	257.80	2,387.22	9,124.48	1,480.08	13,937.14
Maine		1,302.88	3,370.06	5,913.18	484.80	11,070.92
Maryland	4,081.46	414.30	5,932.21	4,417.88	3,030.43	17,876.28
Massachusetts		1,306.30	4,326.78	2,549.91	492.49	8,675.48
Michigan		1,346.18	14,244.40	7,532.34	2,822.42	25,945.34
Minnesota	1,078.07	2,513.91	9,649.10	14,624.96	6,496.81	34,362.85
Mississippi	52,153.91	354.44	5,075.22	35,991.15	769.86	94,344.58
Missouri	3,086.06	345.76	11,433.26	15,284.83	4,882.84	35,032.75
Montana		501.96	1,447.00	6,784.39	1,670.00	10,403.35
Nebraska	1,055.03	310.25	9,247.72	12,502.65	16,068.96	39,184.61
Nevada		539.02	1,376.33	483.35	4,225.90	6,624.60
New Hampshire	2,965.81	663.75	2,961.79	1,155.16	21.00	7,767.51
New Jersey		1,647.34	4,252.56	19,434.44	1,424.00	26,758.34
New Mexico	499.33	91.03	2,129.50	3,084.04	1,914.38	7,718.28
New York:						
Cornell	1,513.24	2,464.54	23,521.62	10,769.71	2,785.23	41,054.34
State		1,838.67	581.50	288.19		2,708.36
North Carolina	7,960.64	43.62	6,089.09	4,567.89	1,467.20	20,128.44
North Dakota		376.07	4,935.12	9,388.25	965.98	15,665.42
Ohio	91.89	981.75	7,031.44	15,446.75	14,753.92	38,305.75
Oklahoma	89,948.34	797.19	11,740.51	16,231.72	20,967.34	139,685.10
Oregon	161.42	323.88	7,078.93	6,550.65	13,670.15	27,785.03
Pennsylvania		324.76	8,756.82	6,286.49	2,002.73	17,370.80
Puerto Rico	999.89	962.30	7,799.88	4,331.05	50.00	14,143.12
Rhode Island	1,399.01	417.73	1,964.79	1,640.07		5,421.60
South Carolina	43,996.43	1,321.65	11,094.18	9,850.41	6,011.45	72,274.12
South Dakota		490.39	6,187.24	1,376.08	10,346.57	18,400.28
Tennessee	21,691.37	511.28	848.88	4,714.34	10,472.52	38,238.39
Texas	20,703.33	11,388.31	11,507.85	15,229.90	25,119.44	83,948.83
Utah		1,283.84	1,813.34	2,367.75	419.80	5,884.73
Vermont		303.17	3,312.04	649.26	96.00	4,360.47
Virginia	3,598.95	1,367.81	5,936.74	4,083.03	576.42	15,562.95
Washington	2,818.52	1,135.07	5,678.39	17,043.31	1,429.05	28,104.34
West Virginia	1,463.34	58.47	3,261.58	5,561.69	1,576.26	11,921.34
Wisconsin	9,954.87	200.00	15,958.02	6,162.33	477.19	32,752.46
Wyoming	184.00	127.01	2,296.01	2,045.92	2,248.34	6,901.28
Total	545,905.49	61,514.50	343,717.84	428,370.82	234,184.19	1,613,692.84

TABLE 10.—*Disbursements from the U. S. Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, Mar. 16, 1906, Feb. 24, 1925, May 16, 1928, Feb. 23, 1929, June 29, 1935, and June 20, 1936*

State or Territory	Hatch Act		Adams Act		Purnell Act		Bankhead-Jones Act	
	1888–1937	1938	1906–37	1938	1926–37	1938	1936–37	1938
Alabama	$748,946.42	$15,000.00	$446,619.89	$15,000.00	$620,000.00	$60,000.00	$62,021.34	$62,021.34
Alaska	90,000.00	15,000.00		7,500.00			1,677.36	1,677.36
Arizona	714,803.10	15,000.00	449,955.61	15,000.00	620,000.00	60,000.00	9,316.92	9,316.92
Arkansas	748,139.12	15,000.00	449,900.00	15,000.00	620,000.00	60,000.00	47,987.40	47,987.40
California	750,000.00	15,000.00	449,926.84	15,000.00	620,000.00	60,000.00	49,456.47	49,456.47
Colorado	749,718.82	15,000.00	448,638.93	15,000.00	620,000.00	60,000.00	16,823.22	16,823.22
Connecticut	750,000.00	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	15,493.56	15,493.56
Dakota Territory	56,250.00							
Delaware	748,382.87	15,000.00	445,475.12	15,000.00	616,924.01	60,000.00	3,757.65	3,757.65
Florida	749,966.04	15,000.00	449,996.06	15,000.00	616,523.74	60,000.00	23,101.23	23,101.23
Georgia	745,593.43	15,000.00	437,092.87	15,000.00	620,000.00	60,000.00	65,642.19	65,642.19
Hawaii	119,919.17	15,000.00	74,951.14	15,000.00	20,000.00	20,000.00	6,889.80	6,889.80
Idaho	674,324.13	15,000.00	445,842.22	15,000.00	620,000.00	60,000.00	10,288.92	10,288.92
Illinois	748,164.43	14,999.96	449,794.91	14,999.75	617,445.71	60,000.00	64,743.61	65,051.92
Indiana	749,901.19	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	44,804.48	47,041.95
Iowa	750,000.00	15,000.00	450,000.00	15,000.00	617,965.17	60,000.00	48,640.98	48,640.98
Kansas	749,995.00	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	37,538.22	37,538.22
Kentucky	749,996.57	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	59,203.53	59,203.53
Louisiana	750,000.00	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	41,350.08	41,350.08
Maine	749,999.62	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	15,519.12	15,519.12
Maryland	749,967.40	15,000.00	449,236.48	15,000.00	620,000.00	60,000.00	21,412.86	21,412.86
Massachusetts	749,617.70	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	13,636.65	13,636.65
Michigan	749,676.10	15,000.00	446,341.20	15,000.00	620,000.00	60,000.00	50,225.88	50,225.88
Minnesota	749,917.78	15,000.00	449,345.00	15,000.00	620,000.00	60,000.00	42,598.23	42,598.23
Mississippi	750,000.00	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	54,488.55	54,488.55
Missouri	745,097.24	15,000.00	449,999.90	15,000.00	620,000.00	60,000.00	57,725.85	57,725.85
Montana	660,000.00	15,000.00	447,417.04	15,000.00	620,000.00	60,000.00	11,627.37	11,627.37
Nebraska	749,932.16	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	29,082.45	29,082.45
Nevada	719,214.32	15,000.00	448,180.28	15,000.00	620,000.00	60,000.00	1,845.48	1,845.48
New Hampshire	750,000.00	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	6,267.90	6,267.90
New Jersey	749,949.97	15,000.00	449,392.06	15,000.00	620,000.00	60,000.00	22,894.38	22,894.38
New Mexico	714,509.05	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	10,320.75	10,320.75
New York	749,757.18	15,000.00	449,187.18	15,000.00	619,904.18	59,999.98	67,373.61	67,373.73
North Carolina	750,000.00	15,000.00	450,000.00	15,000.00	620,000.00	60,000.00	76,971.00	76,971.00
North Dakota	691,502.26	15,000.00	449,638.85	15,000.00	619,994.14	60,000.00	18,506.82	18,506.82
Ohio	750,000.00	15,000.00	448,514.02	15,000.00	620,000.00	60,000.00	69,761.07	69,761.07
Oklahoma	674,002.16	15,000.00	429,535.19	15,000.00	620,000.00	60,000.00	51,338.13	51,338.13
Oregon	735,156.64	15,000.00	445,000.00	15,000.00	620,000.00	60,000.00	15,131.85	15,131.85
Pennsylvania	749,967.43	15,000.00	449,995.41	15,000.00	620,000.00	60,000.00	101,017.14	101,017.14
Puerto Rico	44,822.74	14,980.10	35,304.17	13,498.19	5,000.00	9,782.24	33,303.22	34,667.36
Rhode Island	749,999.65	15,000.00	444,423.50	14,999.57	619,974.75	59,999.63	1,697.88	1,697.88

South Carolina	749, 542. 15	15, 000. 00	448, 460. 12	15, 000. 00	620, 000. 00	60, 000. 00	44, 598. 72	44, 598. 72
South Dakota	693, 250. 00	15, 000. 00	445, 000. 00	15, 000. 00	620, 000. 00	60, 000. 00	18, 324. 33	18, 324. 33
Tennessee	750, 000. 00	15, 000. 00	450, 000. 00	15, 000. 00	620, 000. 00	60, 000. 00	56, 087. 91	56, 087. 91
Texas	750, 000. 00	15, 000. 00	447, 592. 26	15, 000. 00	620, 000. 00	60, 000. 00	112, 023. 57	112, 023. 57
Utah	615, 000. 00	15, 000. 00	449, 821. 94	15, 000. 00	620, 000. 00	60, 000. 00	7, 877. 76	7, 877. 76
Vermont	750, 000. 00	15, 000. 00	450, 000. 00	15, 000. 00	620, 000. 00	60, 000. 00	7, 853. 70	7, 853. 70
Virginia	747, 824. 12	15, 000. 00	449, 949. 01	15, 000. 00	619, 994. 27	60, 000. 00	53, 358. 42	53, 358. 42
Washington	687, 102. 65	15, 000. 00	446, 080. 11	15, 000. 00	620, 000. 00	60, 000. 00	22, 136. 79	22, 136. 79
West Virginia	749, 795. 53	15, 000. 00	447, 013. 82	15, 000. 00	619, 942. 89	60, 000. 00	40, 360. 08	40, 360. 08
Wisconsin	750, 000. 00	15, 000. 00	450, 000. 00	15, 000. 00	620, 000. 00	60, 000. 00	45, 168. 66	45, 168. 66
Wyoming	735, 000. 00	15, 000. 00	450, 000. 00	15, 000. 00	620, 000. 00	60, 000. 00	5, 069. 64	5, 069. 64
Total	35, 634, 704. 14	764, 980. 06	21, 623, 621. 13	755, 997. 51	29, 773, 668. 86	2, 909, 781. 85	1, 794, 342. 72	1, 798, 252. 77

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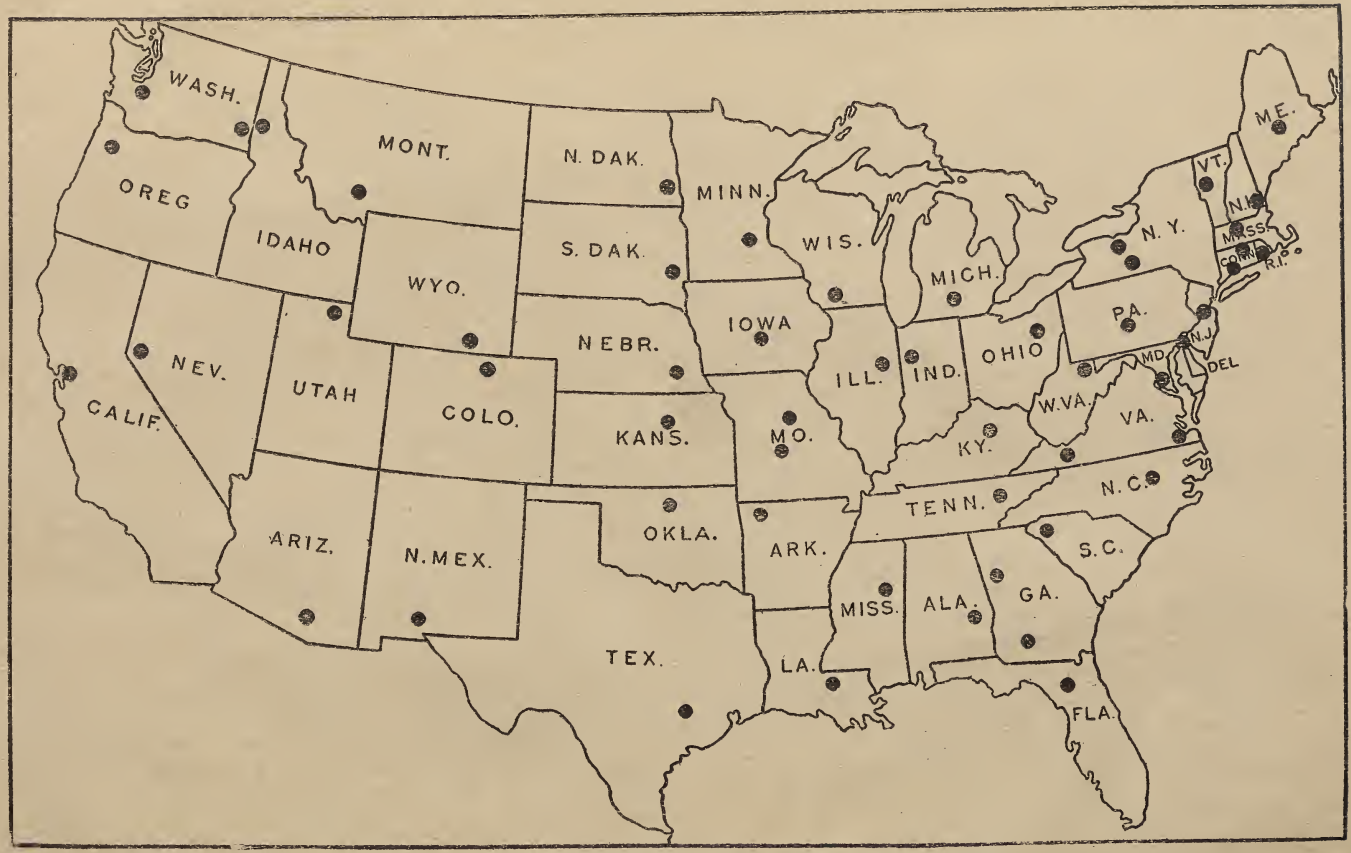

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